CBE

STYLE MANUAL

Council of Biology Editors Style Manual

CBE Style Manual

Third Edition

Prepared by the
COMMITTEE ON FORM AND STYLE
of the Council of Biology Editors

Published for the Council of Biology Editors by the
AMERICAN INSTITUTE OF BIOLOGICAL SCIENCES
3900 Wisconsin Avenue NW, Washington, D.C. 20016

The text paper used in this edition is Simpson Lee 100% Recycled paper. Simpson Lee 100% Recycled text is manufactured from waste materials purchased from waste dealers and other sources. They include obsolete computer print outs, old business correspondence, and printed materials.

Library of Congress Catalog Card Number 60—15133

Copyright 1960 under the title
Style Manual for Biological Journals
by Conference of Biological Editors

Copyright © 1964 under the title
Style Manual for Biological Journals (second edition)
by Conference of Biological Editors

Copyright © 1972 under the title
CBE Style Manual (third edition)
by Council of Biology Editors

Correct citation:

Council of Biology Editors, Committee on Form and Style. 1972.
CBE style manual. Third edition. American Institute of Biological Sciences, Washington, D.C.
All orders should be addressed to
American Institute of Biological Sciences
3900 Wisconsin Avenue NW, Washington, D.C. 20016

Preface

TO THE THIRD EDITION

The committee that produced the First Edition of the *Style Manual for Biological Journals* has been in continuous existence for more than a decade. Even though the name of the parent organization was changed from the Conference of Biological Editors to the Council of Biology Editors, the Committee on Form and Style continued to function under its original title and, with a gradual change in personnel, to collect material and produce later editions.

The Third Edition, a thorough reorganization and an enlargement of the first two editions, has been given the title by which the book has become known among biologists: *CBE Style Manual.*

Incorporated in the Third Edition is material from such international and national bodies as the International Council of Scientific Unions, the International Organization for Standardization, the World Health Organization, and the American National Standards Institute.

In the important area of scientific symbols, abbreviations, and conventions, agreement within and between groups representing the various disciplines and subdisciplines of biology is notably lacking. The function of a manual of this kind is not to usurp the duties of these groups by attempting to set standards or reconcile differences. Consequently, the Third Edition may appear to be inconsistent in some sections, incomplete in others. An objective of sponsors of the *CBE Style Manual* has been to encourage the standardization of editorial practices in biology. The various groups concerned with standardizing symbols, abbreviations, and conventions are urged to hasten ongoing efforts and, where needed, to inaugurate new efforts to standardize these elements and thereby improve scientific communication within and between disciplines, nationally and internationally.

Although the Third Edition includes much more information than previous editions, particularly in highly specialized fields, a large amount of material considered by the Committee on Form and Style had to be omitted to keep the book within reasonable limits. Information was lacking or unavailable for some areas in biology, and as a result they have not received the attention they deserve. Abbreviations of words used in titles of journals have been omitted; they are easily available elsewhere.

Many persons have had a part in producing the Third Edition. In addition to the committee members listed at the end of this preface were three individuals who served for only part of the time the committee was working on the Third Edition: William C. Steere and Elaine G. Cherry, both of the New York Botanical Garden, and Gabriel W. Lasker of Wayne State University.

Among persons who gave advice on general editorial matters were Karl F. Heumann and his staff at the Federation of American Societies for Experimental Biology, Sara F. Leslie and her copy editors in the offices of the American Physiological Society, Philip B. Gove of the G. & C. Merriam Company, and Bruce Young of the University of Chicago Press.

Among those who gave assistance in bibliographic search were Lyle E. Bamber of the University of Illinois, Doris Dodds of the Illinois Natural History Survey, and Robert Mautner of the University of Arizona.

Consultants in the preparation of Chapter 4 include the persons named after the section titles below.

Botany, Zoology, and Microbiology: Robert A. Evers, Philip W. Smith, Lewis J. Stannard, and Igor Tamm.

Anatomy: Raymund L. Zwemer.

Genetics and Cytogenetics: Murray L. Barr, Benjamin H.

Beard, Charles R. Burnham, Ernst W. Caspari, Samuel Goodgall, E. H. Grell, W. C. D. Hare, David A. Hungerford, G. Kimber, Harold P. Klinger, Victor A. McKusick, John G. Moseman, Arno Motulsky, Marcus M. Rhoades, Charles M. Rick, Ernest R. Sears, Marr D. Simons, and Joan Staats.

Immunology: D. B. Amos, K. Frank Austen, William J. Donawick, Henry G. Kunkel, Max Samter, N. Raphael Shulman, J. Wayne Streilein, and Roy L. Walford.

Hematology: Neva Abelson, Robert W. Bull, Samuel Charache, Paul Heller, Hermann Lehmann, Hugh Bilson Lewis, Paul A. Marks, John B. Miale, Arno Motulsky, Oscar D. Ratnoff, Donald L. Rucknagel, and Alexander Wiener.

Physiology (Respiratory): E. J. Moran Campbell, D. J. C. Cunningham, Arthur DuBois, and Joseph C. Ross.

Experimental Materials: Helen Cesvet, Sergey Fedoroff, Samuel M. Poiley, J. Christopher Rigg, and J. Walker-Love.

Chemistry and Biochemistry: Eleanore Butz, Waldo E. Cohn, John T. Edsall, David Seligson, and the late Ernest Cotlove.

Statistics: Horace W. Norton.

Geography and Geology: John M. Dennison.

Russian Alphabet: Jerrold Orne and Linda Schneider.

Members of the Committee on Form and Style are grateful to contributors and consultants for their materials, advice, and criticism. The listing of their names does not imply that either contributors or consultants take responsibility for the content of sections pertinent to their disciplines.

To the many persons (including accurate and painstaking, but unnamed, typists) who helped to produce this book the committee expresses its gratitude.

Throughout their work on the Third Edition, members of the committee were acutely aware of the significant contributions of the science editors who produced the First Edition and the Second. The names of the individuals, some of them now deceased, are as follows:

Committee on Form and Style for First Edition—J. R. Porter, *Chairman,* Sheridan Baker, George B. Cummins, Harold Cummins, Graham DuShane, Richard H. Manville, Robert V. Ormes, A. J. Riker, William C. Steere, H. B. Vickery.

Committee on Form and Style for Second Edition—J. R. Porter, *Chairman,* James S. Ayars, Harold Cummins, Graham DuShane, Richard H. Manville, Robert V. Ormes, A. J. Riker, William C. Steere, H. B. Vickery.

A statement in the preface of the First Edition applies to the Third: "If this manual is to be useful, it must be kept up to date by frequent revision. Comments by users will be helpful."

Comments and suggestions should be addressed to the Committee on Form and Style, Council of Biology Editors, in care of the American Institute of Biological Sciences, 3900 Wisconsin Avenue NW, Washington, D.C. 20016.

Committee on Form and Style
JAMES S. AYARS, *Chairman*
PHILIP L. ALTMAN
MARGARET BROADBENT
EDWARD J. HUTH
DAVID R. LINCICOME
ROBERT V. ORMES

Contents

1 Planning the Article 1
- Introduction 1
- Form of the Article 1
- The Supporting Evidence 3
  - Tables 3
  - Illustrations 4
  - Published and Unpublished Authority 4

2 Writing the Article 5
- The Point of View 5
  - Person 5
  - Tense 5
  - Voice 5
- The First Draft 7
  - Introduction 7
  - Materials and Methods 7
  - Results 7
  - Discussion 8
  - Acknowledgments 8
  - Heads and Subheads 8
  - Footnotes to Text 8
  - Citing Reference Material 9
    - Name-and-Year System 9
    - Number System 10
    - Unpublished Material 10
    - Unread Published Material 10
  - Tables and Illustrations 11
- Early Revisions 11
- Later Revisions 12
- Vocabulary 14
  - Jargon 14
  - New Words 15
    - Formation of New Nouns 16
    - Formation of New Verbs 16
- Word Usage 17
  - Verbs and Nouns 17
  - Nouns as Modifiers 18
  - Overusing Nouns and Relative Pronouns 18
  - Overusing *Of* and *Which* 18
  - Dangling Participles and Infinitives 19
  - *That* and *Which* 19
  - Confusing Pairs 20
  - *While, Although; Since, Because* 21
  - Technical Terms 21
  - Hedging 22
  - Simile and Metaphor 22
- Examples of Faulty Writing 23

3 Mechanical Conventions 27
- Introduction 27
- Punctuation 27
  - Period 28
    - Spaced Periods or Ellipsis Marks 30
    - Raised Period 30
    - Comma 31
    - Semicolon 34
    - Colon 34
    - Question Mark 35
    - Exclamation Mark 35
    - Dashes 35
    - Parentheses 36
    - Brackets 36
    - Apostrophe 37
    - Quotation Marks 38
    - Hyphen 39
    - Slant Line 40
    - Series and Enumerations 41
    - Diacritical Marks 42
    - Italics and Capitals 43
  - Compound Terms 43
  - Derivatives 45

- Abbreviations and Symbols 46
  - In Text Matter 46
  - In Title, Abstract, Translation 47
  - In Figures and Tables 47
  - For Geographic and Geologic Names 48
  - For Names of Chemicals and Drugs 48
  - For Names of Units of Measure 48
  - For Scientific Names 49
  - In Specialized Fields 50
  - Writing Abbreviations 50
- Reporting Numbers 50
- Writing Numbers 51
- Reporting Time 52
- Metric and Decimal Systems 53

4 Style in Special Fields 59
- Introduction 59
- Botany, Zoology, and Microbiology 59
  - Basic Systematic Categories 60
  - Infraspecific Categories 61
  - Horticultural Varieties 62
  - Citation of Author 62
  - Typography 63
  - Vernacular or Common Names 63
  - Keys for Identifying Organisms 65
  - Literature Cited in This Section 67
- Anatomy 68
  - Literature Cited in This Section 69
- Genetics and Cytogenetics 69
  - Bacteria 70
    - Genotype Symbols 70
    - Phenotype Abbreviations 71
    - Strain Designations 71
  - Yeast 72
  - Maize 72
  - Wheat 72
  - Oats 72
  - Flax 72
  - Tomato 73
  - Fruit Fly 73
  - Mouse 74
  - Cat 75
  - Man 76
  - Literature Cited in This Section 78
- Immunology 79
  - Human Immunoglobulins 79
  - Human Complement 81
  - Human Histocompatibility Leukocyte Antigens 81
  - Literature Cited in This Section 82
- Hematology 82
  - Blood and Serum Groups 83
    - Human Blood Groups 83
    - Infrahuman Blood Groups 83
    - Human Serum Groups 83
    - Human Clotting Factors 84
  - Hemoglobins 84
    - Human Hemoglobins 84
    - Infrahuman Hemoglobins 86
  - Human Glucose-6-Phosphate Dehydrogenase 86
  - Literature Cited in This Section 87
- Physiology 88
  - Thermal Physiology 90
  - Respiratory Physiology 92
  - Literature Cited in This Section 93
- Experimental Materials 93
  - Animal Tissue Culture 94
  - Animals 94
  - Literature Cited in This Section 96

Chemistry and Biochemistry 96
  Nonproprietary Names 96
  Proprietary Names 97
  Abbreviations 98
  Symbols and Formulas 98
  Nuclides and Isotopes 100
  Equations 101
  Water of Hydration 101
  Configuration and Rotation 101
  Solutions 102
  Analytical and Other Methods 103
  Physical Properties 103
  Spectrophotometry 104
  Centrifuging 104
  Chromatography 105
  Metabolic Quotients 105
  Enzymes 106
  Ribonucleic Acid 106
  Polypeptides and Other Polymers 106
  Carbohydrates 109
  Lipids 110
  Steroids 110
  Reprints 110
  Literature Cited in This Section 110
Mathematical Formulas and Equations 112
  Identifying Characters 112
  Using Italics 113
  Simplifying Equations 113
  Presenting Complex Equations 113
Statistics 116
  Symbols and Abbreviations 118
  Literature Cited in This Section 119
Geography and Geology 119
  Stratigraphic and Geologic Time Divisions 120
  Literature Cited in This Section 120
Greek Alphabet 121
Russian Alphabet 122, 123

5 Preparation of Copy 125
Introduction 125
Title 126
By-Line 127
Abstract 128
Key Words, Indexing Terms, or Descriptors 130
Running Head 130
Heads and Subheads 131
Acknowledgments 132
Footnotes to Text 132
Published and Unpublished Authority 133
Tables 136
  The Parts of Tables 136
  Table Numbers 137
  Table Titles 137
  Cross Rules 137
  Vertical Rules 137
  Alignment in Columns 139
  Factors in Column Headings 140
  Symbols and Abbreviations 141
  Footnotes to Tables 141
  Leaders in Tables 141
  Typing of Tables 141
Illustrations 142
  Line Ilustrations 143
  Photographs and Continuous-Tone Drawings 145
  Dimensions and Scaling 146
  Lettering Illustrations 148
  Marking Illustrations 150
  Checking Figure Numbers and Citations 151
  Legends 151
List of References 152

      Style for Name-and-Year System 153
      Style for Number System 153
      Name(s) of Author(s) 154
      Year of Publication 157
      Title of Article or Book 158
      Name of Periodical 159
      Volume, Issue, and Pages of Periodical 160
      Volumes and Pages of Book 161
      Illustrations 161
      Missing Bibliographic Details 161
   Examples of Bibliographic Entries 162

6 The Final Draft 167
   Introduction 167
   Paper 167
   Typing 167
   Reading Copy 168
   Making Corrections and Insertions 169
   Indicating Positions for Figures and Tables 169
   Final Checklist 170
   Submitting the Manuscript 171

7 Review of Manuscripts 173
   Introduction 173
   Good Practice for Referees 174
   Checklist for Referees 175

8 Manuscript into Type 179
   Introduction 179
   Specifications 180
   Typographical Conventions 182
      Italics 182
      Small Capitals 183
      Capitals 183
      Boldface 185
   Estimating Number of Printed Pages 185
   Copy Edited and Marked 186

9 Proof 187
   Introduction 187
   Reading Proof 188
   Marking Proof 189
   Proofreader's Symbols and Marks 190
   Correcting Typewriter Composition 194
   Checking Word Division 194
   Proof of Illustrations 195
   Handling Proof for Overseas Authors 197

10 Indexing 199
   The Approach to Indexing 199
   The Elements of the Index 200
   The Mechanics of Indexing 200
   The Typography of Indexes 204

11 Word List 205

12 Abbreviations 219

13 Annotated Bibliography 249
   Style Manuals, Grammars, Writing and Printing Guides 249
   Dictionaries and Source Books 256
   Indexes and Periodical Lists 260
   Standards and Codes 261
   Handbooks 265
   Zoological Nomenclature 267
   Botanical and Microbiological Nomenclature 271

14 Literature Cited 275

Index 279

1. Planning the Article

INTRODUCTION

A written report of the results is an integral part of your research. To yourself and your readers you owe accurate, clear, and concise writing. To the journal that publishes your manuscript you owe brevity; printing costs are high and competition for space is keen.

FORM OF THE ARTICLE

The scientific report, paper, or article is a record of work done, results observed, and conclusions drawn. Most articles in biological journals contain four main parts or sections: Introduction, Materials and Methods, Results, and Discussion. A few contain a section headed Conclusions or Conclusions and Discussion, and some a section entitled Summary.

In addition to the main sections, all articles include a Title and most of them a By-Line, Abstract, Acknowledgments, and Literature Cited or References.

Articles in some journals include a list of words useful for indexing. The importance of these words, known as Key Words, Indexing Terms, or Descriptors, will increase as greater dependence is placed on computers for retrieving information.

In planning your paper, study the forms of the articles in the journal for which you intend to write and select the form that best fits your subject and the probable length of your paper.

Unless your article is to be very short, you will need a written outline. For most articles, the outline should be built on the standard form: Introduction, Materials and Methods, Results, Discussion. This form is so useful and so well established that you should deviate from it only after careful consideration.

A long and complicated article may require a variation in the standard form; for example, after an Introduction for the entire article, you might write a Materials and Methods section and a Results section for each of several subdivisions and a single Discussion section for the entire article.

If you have accurately and systematically recorded your observations, results, conclusions, references, and other pertinent information on file cards or on sheets in a loose-leaf notebook, you should be able to arrange the cards or sheets in logical sequence and write your outline—or even the first draft of your article—from them. Keep in mind that the outline is to be your servant and not your master.

You may wish to write a tentative title and abstract while planning your article. The exercise involved in writing title and abstract at this time should help you to evaluate your results, discard irrelevant data, and place the various elements in their proper relationships. Later you should examine the tentative title and abstract critically and, if necessary, rewrite them. Because the title and abstract are the first channels through which most readers will learn of the research you are reporting, they should be clearly representative of your article and your work.

The form of the by-line does not need to concern you until you are nearing the final draft of your article, but the persons to be included as authors should be agreed upon before you begin the first draft. Do not list as an author any person who has not participated *materially* in the planning, execution, or analysis of the research. An early decision about authorship may prevent later misunderstanding and embarrassment. The practice of including in the by-line the name of a person who has not actually engaged in the reported research is considered by many scientists to be unethical. One of the chief offenders in this practice is the institutional superior who insists that his name appear in the by-line of every paper produced under his supervision.

THE SUPPORTING EVIDENCE

The data you have collected in your research, the observations you have made, and the reading you have done have led you to certain conclusions. The accumulated information lies before you as notes, tables, graphs, and possibly other illustrations. At this stage none of the material is likely to be in final form, but it should be accurate and readily accessible.

You are now faced with the task of deciding how best to present this material to the reader as evidence to support your conclusions. The following pages give suggestions. So do many articles and books on technical writing. See especially some of the books listed in Chapter 13 under "Style Manuals, Grammars, Writing and Printing Guides."

Examine your supporting evidence objectively. Put aside any that is not clearly relevant to your purpose in writing the article. Assemble the tables, graphs, and other supporting evidence and arrange them in the order called for by your outline. Reexamine each unit of evidence and question its form and suitability. For example, question whether the data in a certain graph might be more useful to the reader if presented in a table, whether the data in a certain table might convey more information in less space if incorporated in the text, or whether data gleaned from the text of a published article you are citing might have more meaning if depicted in a graph.

TABLES

See also pages 11 and 136

Although tables are usually the most effective means for presenting masses of numerical data, you should not attempt to force into tabular form those data that can be presented more appropriately or economically in graphs or in the text.

Editors and referees are likely to scrutinize your tables closely and may suggest extensive revision or even elimination of some of them. The cost of setting a page of tabular matter in type is two to five times the cost of setting a page of text.

ILLUSTRATIONS

See also pages 11 and 142

After you have completed your outline, examine your illustrations in relation to the article you plan to write. Decide which ones should be discarded because they are not sufficiently relevant to your central thesis and which should be replaced by illustrations of better quality or more suitable types. Decide also whether you are lacking illustrations that could contribute effectively to a reader's understanding of your methods or conclusions. Of the several types of illustrations—maps, graphs, line drawings, tone drawings, photographs—choose the one best suited for each situation. Arrange to have any new or replacement illustrations completed by the time you have finished writing your article.

Do not plan to use color illustrations, which are costly to reproduce, unless you have the approval of your journal editor. Color transparencies are preferable to color prints for most color work. A good black-and-white print can be made from a color slide of high quality.

PUBLISHED AND UNPUBLISHED AUTHORITY

See also pages 9, 133, and 152

Reproduction of the published or unpublished material of other authors may require written permission of the authors, their publishers, or both the authors and their publishers. For this and other reasons, your notes on published material should include full bibliographic details, accurately and systematically recorded on file cards, a separate card for each article or book.

While planning your article, decide what passages you wish to quote and what illustrations you wish to reproduce from published articles or books. Familiarize yourself with the laws and customs related to authorship of both published and unpublished work; then begin at once your efforts to obtain any releases needed. Delay in obtaining releases might delay publication of your article.

2. Writing the Article

THE POINT OF VIEW

Having completed your research, assembled your supporting evidence, and outlined your article, you should be ready to begin the writing, a highly individual process. Maintain a consistent point of view toward yourself, your research, and your reader through proper use of person, tense, and voice.

PERSON

Decide early which person—first, second, third—you will adopt for each of the various phases of your writing. The first person (*I, we*) is natural for relating what you did. The second (*you* expressed or *you* not expressed but understood) is convenient for giving directions. The third (*he, she, it, they,* or a substantive) has definite advantages for telling what happened.

TENSE

Follow a logical pattern of tenses. Record observations and completed procedures in the past; write directions, generalizations, and references to stable conditions in the present tense.

VOICE

Write in the active voice unless you have a good reason for writing in the passive. The active is the natural voice, the one in which people commonly speak and write, and it is less likely than the passive to lead to ambiguity.

Avoid the "passive of modesty," a favorite device of writers who shun the first person singular. "I discovered" is shorter and less likely to be ambiguous than "it was discovered." When you write "experiments were conducted," the reader cannot tell whether you or some other scientist conducted them. If you write "I" or "we" ("we" for two or more authors, never as a substitute for "I"), you avoid the possibility of dangling or "hitchhiking" participles and infinitives, common in sentences written in the third person passive voice. (See "Dangling Participles and Infinitives," under "Word Usage," this chapter.) Do not substitute "the writer" for "I." "I" may embarrass the writer, but it is less likely to be ambiguous, as shown in the following example, in which "the writer" may be either Smith or the author of the two sentences:

These analyses, according to Smith, were inconclusive. The writer believes that the samples analyzed were collected from areas unknown to him.

Any of the following substitutes could replace the second sentence, and no one but its author is in a position to know which is correct.

I believe that the samples analyzed were collected from areas unknown to me.

Smith believes that the samples analyzed were collected from areas unknown to him.

I believe that the samples analyzed were collected from areas unknown to Smith.

Athough frequently misused and abused, the passive voice has justifiable functions in technical writing. It may serve when you believe the agent of action (the publisher in the example below) is irrelevant and need not be mentioned:

Darwin's *Origin of Species* was published in 1859.

It may serve when you wish to emphasize something or someone other than the agent. Whether you write "antibiotics are produced by fungi" or "fungi produce antibiotics" may depend upon whether you wish to emphasize antibiotics or the agent, fungi. The passive voice may sometimes help you avoid an unnecessary and perhaps awkward change of subject. Compare these sentences:

This paragraph implies that the experiment performed itself or was performed by a robot.

This paragraph implies that the experiment performed itself or that a robot performed it.

THE FIRST DRAFT

For writing your first draft, choose the place, time, and method that suit you best. You will probably find that you do your most effective writing in a quiet place and at specific times—early in the morning or in the evening or after midnight. You may prefer to write rapidly, putting down ideas with little regard for sentence structure, or you may have better success in writing slowly, making revisions as you proceed.

INTRODUCTION

Begin your article with a clear identification of its subject. State your hypothesis or define the problem your research was designed to solve. Orient your article in time, possibly by a review of literature that is unmistakably relevant to the problem or the hypothesis.

MATERIALS AND METHODS

Describe your materials and methods in sufficient detail to enable other scientists to evaluate your work or to duplicate your research procedure.

Avoid cluttering your paper with unnecessary details. If in your work you used a well-known method without modification, name the method or, at most, cite the article in which it is described. If you modified the method, describe the modification.

RESULTS

Present the results of your research in orderly and coherent sequence. Include only such data and illustrative material as are pertinent to the subject of your paper. Do not omit important negative results. In this section avoid extensive discussion.

DISCUSSION

In discussing your project, interpret the data presented in the section on results, giving particular attention to the problem or hypothesis posed in your introduction. Do the data support your hypothesis? Do they provide answers to the questions that led to the design and execution of your study? Relate your findings to previous observations or experiments by yourself or others. Include findings that do not agree with yours. Discuss briefly any logical implications of your findings for practical application or future studies.

Some journals permit a Conclusions as well as a Discussion section.

ACKNOWLEDGMENTS

See also page 132

Even before you begin your first draft, start making a list of persons and agencies whose help in research or writing you wish to acknowledge. Delay writing a formal Acknowledgments section until your paper is nearing completion.

HEADS AND SUBHEADS

See also page 131

The titles of the main sections of your article (Materials and Methods, Results, Discussion) may serve as heads for indicating the organization of your text. In a lengthy article, subheads in sections will serve as guides to you as you write the article and to your readers later. The outline of your paper should be a good source for subheads. In a short article, subheads may not be needed.

When working on the first draft, do not spend time on rewording subheads. You can revise them later.

FOOTNOTES TO TEXT

See also page 132

Use footnotes to the text only when they are clearly necessary for presenting documentary or explanatory material, that is, when the material is important and its inclusion in the text would be distracting.

Do not use footnotes to abstracts. Some journals do not sanction footnotes to titles.

CITING REFERENCE MATERIAL

See also pages 4, 133, and 152

In citing reference material, which should eventually be listed in a bibliographic section titled Literature Cited, References Cited, or References, follow the practice of the journal for which you are writing. References and References Cited may include unpublished as well as published material. Literature Cited should include only material that has been published, or is actually scheduled for publication, and theses or dissertations that are readily accessible.

Two systems of citation are common among biological journals: the name-and-year (or author-date) system and the number system.

Name-and-Year System. In journals following the name-and-year system, the name(s) of the author(s) and the year of publication are included in a text citation, as shown below. See also page 153. The placement of the parentheses depends on sentence structure.

One author: Bellrose (1950) *or* (Bellrose 1950)
Two authors: Bellrose and Lowe (1950) *or* (Bellrose and Lowe 1950)
Three or more authors: Bellrose et al. (1950) *or* (Bellrose et al. 1950)
Bellrose et al. (1950) reported that wood ducks were once abundant in Illinois.
Wood ducks were once abundant in Illinois (Bellrose et al. 1950).

Some journals set a comma, which appears to serve no practical purpose, between the name(s) of the author(s) and the date:

(Bellrose, 1950) (Bellrose and Lowe, 1950)

For the text reference to a committee or government report or other publication having no individual listed as author, the sponsoring organization or, if named, the chairman or editor is the "author." See examples at the end of Chapter 5.

In the citation of a book of more than one edition, two dates may be given: the date of the edition cited and the date of the first edition (see "Year of Publication," Chapter 5).

Some journals require their authors to include in each citation except a general reference the page number(s) on which the cited material can be found:

(Starrett 1964:75–79) *or* (Starrett 1964, pp. 75–79)

This practice is a convenience to editors and readers for locating and verifying paraphrased or quoted material. Thus, it encourages accuracy by writers who might otherwise be careless in their paraphrasing and quoting.

Number System. (See also page 153.) In some journals that have adopted the number system, only the number assigned to the reference work in the Literature Cited, References Cited, or References is given in the text citation; in others, the name(s) of the author(s) and the number assigned to the reference work are included:

Wood ducks were once abundant in Illinois (3).
Wood ducks were once abundant in Illinois (Bellrose and Lowe 3) *or* (Bellrose and Lowe, 3).
Bellrose and Lowe (3) reported that wood ducks were once abundant in Illinois.

Unpublished Material. An unpublished report or similar work that should not be included in a bibliographic section headed Literature Cited may be referred to in the text by identifying the work, naming its author(s), if known, adding the word *unpublished* in parentheses, and telling where the work can be seen.

You may list in the bibliographic section of most journals, and cite in your text, an unpublished article or book that has been scheduled for publication. The journal editor will probably require that you add to the listing (which may lack page numbers) the notation *in press*.

Although you should not list personal communications in the Literature Cited section, you may refer to such material in a footnote or in the text by stating in parentheses the nature and date of the communication and the name and identity or address of the communicator:

(letter dated 16 April 1970 from Thomas G. Scott, Department of Wildlife Research, Oregon State University, Corvallis, Oregon)

Unread Published Material. The need to cite references not readily available or no longer in existence presents a problem to some biologists, taxonomists in particular. If you must cite a published reference that is not available to you, indicate in some way, possibly by a footnote or a notation in parentheses, that you have not read the reference in the original. The citation "Powell (1858, cited by Forbes 1872)" would indicate that you have depended upon an article written by Forbes and published in 1872 for information in an article written by Powell and published in 1858. You would, of course, list both articles in your bibliographic section and add in parentheses at the end of the Powell entry that you have been unable to see the article and are depending on Forbes (1872) for the information from Powell.

Similar candor is desirable in citing articles published in foreign languages. Indicate either in the text or in the bibliographic section whether you are citing the original article, a translation, or an abstract.

TABLES AND ILLUSTRATIONS

See also pages 3, 4, 136, and 142

Number tables and illustrations in the order in which you want them to appear in your article: one consecutive series for tables (Table 1, Table 2, Table 3) and another for figures (Fig. 1, Fig. 2, Fig. 3). (Illustrations are usually referred to as figures.) Cite each table and figure at least once in the text. You may interject minor citations between the major, consecutively numbered citations, for instance a minor citation to Fig. 3, or even Fig. 10, between the principal citations to Fig. 5 and Fig. 6.

Do not repeat extensively, in the text, the data you have presented in tables and figures. You may, however, offer comments that will contribute to the reader's understanding—for example, interpret data, call attention to trends shown by tables, or point out similarities or differences in comparable figures.

Label figures and tables as soon as you decide to include them with your article. You will probably save time if you delay the final wording of legends for figures and titles for tables until you have completed at least the first draft of your text.

EARLY REVISIONS

After you have finished the first draft, review the structure of your manuscript. Are the sections arranged in logical sequence?

Can the sequence be improved?

Examine the arrangement of paragraphs within sections. Is it logical and orderly? Should some paragraphs be shifted to other sections? Are all relevant to the purpose of the manuscript, or should some be deleted?

In revising your manuscript, you will probably rewrite some pages more than others. If you date each page as you write it, you will be able to tell which is the latest draft. Mark superseded pages as such and keep them on file where you can refer to them for assurance that you have not made errors in transferring data from one draft to another.

Eventually you will decide that further efforts by you alone to improve the structure of the manuscript would be fruitless. You are fortunate if, at this point, you can submit your manuscript to a colleague for a general appraisal. You should weigh his suggestions thoughtfully and objectively. Some you may accept and act upon; others you may or should reject. You must be the judge.

This early consultation with a colleague should be in addition to later detailed criticism by an associate at the time you believe your manuscript is nearing completion.

LATER REVISIONS

After you are satisfied with the structure of your manuscript, attend to the details: the paragraphs, the sentences, and the words; the transitions from section to section and from paragraph to paragraph. Rewrite your article as many times as may be necessary to achieve logical order and maximum clarity of expression.

At least once during the writing period, put your work aside for a few days. After a rest, you should be able to approach your manuscript with renewed enthusiasm and objectivity, to appreciate its strong points, and to correct its faults.

At a late stage of revision, review your manuscript sentence by sentence and word by word. Look for words used incorrectly. Eliminate words that are unnecessary. Recast sentences until they are so clear that they cannot be misunderstood. Although writing can be too compact, excessive wordiness is the more common fault.

By deleting unnecessary words you contribute to clarity, accuracy, and ease of reading. "It is interesting to note that," for instance, does no real work and contributes only dullness. Change such an expression as "It was reported by Smith" to "Smith reported." Watch for *which* and *of* as signs of wordiness.

Test your use of such words as *very, much, more,* and *quite,* which have their rightful places but are frequently misused as super-superlatives. Look for and delete comparatives used with words that express absolute quality or condition. Something cannot be very, quite, more, or most complete, immediate, adequate, sterile, perfect, round, or universal; it may be nearly complete or adequate to a situation.

Give preference to short, simple, widely understood words. Avoid misleading terms and the informal jargon of your field. The term "schizophrenic blood" is a misnomer for "the blood of schizophrenic patients."

Unnecessary repetition, extraneous details, and loose phrases can obscure even simple ideas. Below is a paragraph cited by Riker (1946) from a paper submitted for publication (errors in spelling have not been corrected).

> The multiplication of resistant white pine trees by means of making grafts has been already demonstrated as a feasible possibility. On an experimental basis, as was explained earlier, over 1000 grafts have been made and grown successfully during these studies in both green house and field conditions. Yet a grafted tree has been found relatively expensive because of the necessity, according to present technique, of using green house space in the winter time and cold frames in the spring. Counting scions, stock, pots, labor, *et cetera,* each graft is estimated to cost about 12 cents. This cost might be reduced somewhat if further research will be done to further improve the methods employed. It might also be reduced by puting this operation on the basis of a large scale commercial production. Even at this relatively high figure grafting may now be done as a practical possibility due to the high price paid for certain types of ornimental planting. But the most promising means that has appeared of reducing the cost of propagating rust resistant white pine trees is through the rooting of cuttings.

Much of this verbiage can be weeded out by careful rewriting:

> Propagation of rust-resistant white pine by grafting is feasible, but grafted trees are too expensive (about 12 cents each), except for certain ornamental plantings. Improved technique and large-scale commercial production may reduce the cost of grafted trees, but the use of rooted cuttings seems more promising.

VOCABULARY

The preface to the 24th edition of *Dorland's Illustrated Medical Dictionary* (1965:vii) contains several statements that should be read and heeded by all biologists:

> All learning in science is based on education in vocabulary, for the imagery of words and symbols is the only means to expression of scientific data and concepts. For the continuing successful interchange of ideas, the words and ideographs of science must have precise and specific meanings. . . .
>
> Codification of knowledge is made increasingly difficult by the steadily broadening scope and mounting complexity of contemporary medical science. In this trying situation we believe that writers and editors constitute the first line of defense, particularly against erosion and adulteration of the language. We believe that editors should not be unmindful of the advisability of safeguarding the faithful transmission of ideas, by insuring the integrity of the words in which they are expressed.

JARGON

Researchers in each field of science tend to develop a vocabulary or jargon so peculiar to their activities that it inhibits rather than promotes the interchange of ideas beyond a highly specialized circle.

Among the several definitions of jargon in *Webster's Third New International Dictionary of the English Language, Unabridged* (1961), is the following: "**3 a** : the technical terminology or characteristic idiom of specialists or workers in a particular activity or area of knowledge." In this sense, jargon that meets standards of good etymological practice has a place in formal reports. To be avoided, however, is informal jargon or lingo that is obscure, vague, esoteric, pretentious, inept, or carelessly formed.

Some scientists create a jargon of questionable value by using well-established words in new ways or in senses not generally accepted. A fisheries biologist may write that he "stocked trout in the stream" when he means that he "stocked the stream with trout." A biochemist may write that he "reacted alcohol with acetic acid" or that "alcohol was reacted with acetic acid" or that he had an "unreacted substance" or that "the ether extract was migrated two-dimensionally." In each example in the previous sentence, a word generally recognized as solely an intransitive verb, which does not take an object and has no passive voice, has been used as a transitive. Although *react* as a transitive verb is recognized in both *Webster's New International Dictionary of the English Language, Second Edition, Unabridged* (1941), and *Webster's Third* (1961), and *migrate* as a transitive verb in *Webster's Third,* use of either word as a transitive is limited to a small group and is so rare that the meaning may be vague or obscure to scientists in other fields.

Both authors and editors bear a responsibility for using words precisely and in their established meanings. A word that through imprecise usage by authors and editors has become ambiguous is *dialyzate* (*dialysate*). In *Webster's New International Dictionary of the English Language* (1932), *dialyzate* is defined as follows: "That part of a material subjected to dialysis which fails to pass through the membrane;—opposed to *diffusate*." The definition in *Webster's Third* (1961) reveals the effect of imprecision in use of the word: "a product of dialysis—used either of the material that has failed to diffuse through the membrane or of the diffusate." The definition in *Webster's New International, Second Edition* (1941) illustrates how the ambiguity evolved: "The product of dialysis;—formerly used to designate the material which has failed to pass through the membrane, but now used quite generally to designate the substance which has passed through the membrane. See DIFFUSATE."

NEW WORDS

Do not use a word that is not listed in an unabridged dictionary unless it is widely accepted in formal communications in your field or unless a real need for such a word exists. Consider foreign colleagues who must translate what you have written. Because frequency of appearance of a specialized laboratory term in printed reports helps to determine the ultimate inclusion of the term in a dictionary, authors should write and editors should publish only such new words as are correctly formed and are exact in meaning.

Scientists manufacture technical words—nouns and verbs especially—in several ways. Some of the manufactured words are self-explanatory and fill a real need; others are vague or pretentious substitutes for well-established terms. If scientists are to speak from discipline to discipline in a "continuing succesful interchange of ideas," they must exercise restraint in the manufacture of new words as well as in the creation of new meanings for old words.

Formation of New Nouns. Many nouns currently in good usage have been formed from the suffix *ate* (indicating the result of a process or action) added to a stem implying action. Among nouns of this kind in *Webster's Third* are

exudate **eluate** **diffusate**
photosynthate **homogenate**

Such neologisms as the following are not acceptable:

grindate **shockate** **pressate** **washate**

Formation of New Verbs. Many acceptable verbs have been constructed from the stem of a noun or adjective and the suffix *ize,* meaning to make into or cause to be or to resemble:

colonize **summarize** **oxidize** **stabilize**
neutralize **homogenize** **lyophilize**

Reckless extension of the practice of forming new verbs by adding *ize* to nouns or adjectives is to be avoided; the following have nothing to recommend them in scientific writing:

inoculize **blenderize** **rigidize**

Although many verbs with the suffix *ate* (*concentrate, propagate, fractionate*) are widely accepted, any invented verb, such as *sedimate,* that lacks etymological or scientific justification should be avoided.

WORD USAGE

Use words with precision and economy to construct sentences that are exact, clear, and as simple as the subject permits.

Review your manuscript for accuracy in choice of words. Refer when necessary to a dictionary to determine whether you are using words in their accepted meanings. For a word having synonyms, consider whether it or one of its synonyms best conveys your meaning. Consider, for example, whether two objects are *joined, connected, united, linked, annexed, coupled, associated,* or *attached;* they may even *inosculate* or *anastomose,* or perhaps they merely *communicate* or *interdigitate.*

Make sure that you use technical terms precisely. If your research involved spinach *leaves* or the *flower buds* of cauliflower or carrot *roots,* say so at least once in your paper; if *blood serum,* specify the animal from which it was derived; if *leaves* of tea or tobacco, tell whether they were *green* leaves or the *prepared* leaves of commerce.

VERBS AND NOUNS

Remember that a verb must agree in number with the sense and usually the form of its subject. The writer of the sentence "The tissue was weighed and several samples cut from it" failed to give the second subject its proper plural verb, "were cut."

Most nouns are either singular or plural in both form and sense and require a verb of the same number (the insect is, the insects are). Some are plural in form but usually singular in sense (kinetics is). Some are collectives that are singular in form but may be either singular or plural in sense (school, herd, family). In using a collective noun as a subject, make its verb plural if you think of the subject as individuals; make its verb singular if you think of the subject as a unit. You may often consider units of measure (grams, liters, dollars) in a collective sense: "Ten milliliters of serum was added to the mixture."

Be alert for nouns that have plural forms not ending in *s,* such as *data* (singular *datum*) and *media* (singular *medium*).

NOUNS AS MODIFIERS

Although many nouns can be properly used as modifiers (*horse* fly, *tree* house, *midyear* examination), avoid using them in confusing clusters: (i) "a new *type motor skills college performance* test"; (ii) "a *percentage transmission* recording *ultraviolet light absorption* meter"; (iii) "when the pooled within *photograph* partial *regression equation* was calculated."

When you use a noun as a modifier, do not add an adjective ending if the noun form expresses the meaning you wish to convey. Consider the meanings of these noun and adjective forms: a *science* writer, a *scientific* writer; *nerve* ending, *nervous* ending; *insecticide* application, *insecticidal* application; a *pathology* professor, a *pathological* professor.

OVERUSING NOUNS AND RELATIVE PRONOUNS

Avoid habitual use of nouns or relative pronouns where adjectives, adverbs, or participles would make for conciseness or give variety to sentence structure. Write (i) "the tube, *which is 3 m long*," "the tube, *3 m long*," or "the *3-m tube*" rather than "the tube, *which has a length of 3 m*"; (ii) "the research is *very important* to biologists" or "the research, *very important* to biologists," instead of "the research is *of great importance to biologists*"; (iii) "a technique *that was widely used* 5 years ago" or "a technique *widely used* 5 years ago" instead of "a technique *that was in wide use* 5 years ago"; (iv) "a process for *avoiding waste*" instead of "a process for *the avoidance of waste*."

OVERUSING *OF* AND *WHICH*

Avoid overusing *of* and *which*. Here is a passage (cited by Baker 1956:465) suffering from what may be termed "the of and which disease" (*which* and *of* in the quotation below are italicized for emphasis):

> Many biological journals, especially those *which* regularly publish new scientific names, now state in each issue the exact date *of* publication *of* the preceding issue. In dealing with journals *which* do not follow this practice, or with volumes *which* are issued individually, the biologist often needs to resort to indexes . . . in order to determine the actual date *of* publication *of* a particular name.

By eliminating half of the *of*'s and the nouns they bring in, replacing *which* phrases with participles, and making a few other changes, you can reduce the length of the quoted passage without changing its sense:

> Many biological journals, especially those regularly *publishing* new scientific names, now give the exact date of the preceding issue. In using journals, and some books, not *adhering* to this practice, the biologist must turn to indexes . . . *to date* the publication of a particular name.

DANGLING PARTICIPLES AND INFINITIVES

Dangling or "hitchhiking" participles and infinitives are distressingly common in scientific writing. They occur most frequently in sentences written in the passive voice—sentences in which the real agent of the action suggested by the participle or infinitive is not named. Hence the action is attributed, sometimes with ludicrous implications, to an agent that cannot perform the action:

Judging by present standards, these *trees* are. . . .
Looking through the microscope, the *cells* could be. . . .
Nitrogen was determined, *using* the Kjeldahl method. . . .
To determine the degree of anemia, *hemoglobin* was measured. . . .

The simplest remedy for the first example is to change the present to the past participle, *judging* to *judged,* and bring the subject forward in the sentence. Each of the next two examples profits from a rewording to eliminate the participle. The last example can be improved by identifying the agent and changing the verb in the main clause to the active voice:

These trees, judged by present standards, are. . . .
Under the microscope, cells could be. . . .
Nitrogen was determined by the Kjeldahl method. . . .
To determine the degree of anemia, I measured hemoglobin. . . .

THAT AND *WHICH*

Precise usage favors *that* to introduce a restrictive (defining, limiting) clause and *which* to introduce a nonrestrictive (nondefining, descriptive) clause. Maintaining the distinction between these relative pronouns contributes to clarity and ready understanding. In the sentence "The fish that survived the treatment lived 3 years," the defining clause, "that survived the treatment," is needed to identify the fish being discussed. In the sentence "The third fish, which survived the treatment, lived 3 years," the nondefining or descriptive clause, "which survived the treatment," merely gives additional information about its subject, which has already been identified by the adjective "third." Each of these pronouns signals the special function of the words it introduces—defining or merely describing.

CONFUSING PAIRS

Many pairs of words of somewhat similar meaning confuse beginners and even some experienced writers of scientific papers. *Affect* as a verb means to influence or act upon; *effect* as a noun is the result of the influence, but as a verb it means to *produce, do, make, accomplish,* or *bring about.* In the sentence "To determine stomatal closure in the wilted leaves and how this was *effected* by treatment, I placed detached leaves in water," the meaning is not clear. If the author meant *effect,* he implied that he brought about closure of the stomata by his treatment. But if he really meant *affect,* he was simply proposing to inquire into the cause of the observed event. In one interpretation, he controlled a biological phenomenon; in the other, he did not.

Varying and *various* are not synonymous. The sentence "Light intensity was controlled by cheesecloth shades of *varying* thickness" is inaccurate since no shade changed its thickness during the course of the experiment. The shades were of *various* thicknesses.

To *infer* is to derive by implication or reasoning; to *imply* is to intimate or suggest a meaning not expressed. The Nobel prize money for scientific research may be divided *between* him and me; or it may be divided *among* three or more scientists. An *epidemic* properly refers to a human population, an *epizootic* to lower animals, and an *epiphytotic* to plants. *Prevalence* of a disease refers to the number of cases of illness or of persons ill of the disease in a specified population, without distinction between old and new cases. *Incidence* refers to the number of cases of the disease beginning during a given period in a specified population.

Other words that are sometimes confusing are listed in Chapter 11. When in doubt, consult a dictionary; to *flout* the dictionary is as unwise as to *flaunt* your knowledge.

WHILE, ALTHOUGH; SINCE, BECAUSE

While has long been used with the concessive connotation expressed by *although,* and *since* in the meaning expressed by *because* or *for the reason that.* But both words have a strong sense of time, and either one at the beginning of a sentence may be ambiguous. Each of the two sentences below has two possible interpretations; one interpretation of the first is absurd.

While the peaches are grown in Georgia, most of them are eaten in New York.

Since snow fell yesterday, the roads have been slippery.

Revise any sentence in which either of these words might be ambiguous. Use a substitute word or phrase: *although, but, whereas, even though, even if* instead of *while; because, for, inasmuch as* instead of *since.* Or try making two coordinate clauses with a semicolon between:

The peaches are grown in Georgia; most of them are eaten in New York.

Because snow fell yesterday, the roads have been slippery.

TECHNICAL TERMS

Chapter 11 should serve as a guide to spelling and good usage of words and technical terms common in biology. For words not included in that chapter, consult *Webster's Third New International Dictionary* (1961). Items 1.7.1 and 1.7.2 on page 16a of the front matter of *Webster's Third* give directions for determining the preferred variant of a word having more than one spelling.

Avoid eponymous terms (terms derived from the names of persons) if descriptive but short, standard, and unambiguous terms are available. For example, use "tricarboxylic acid cycle" instead of "Krebs cycle"; use "osteitis deformans" instead of "Paget's disease" (which can refer either to a bone disease or to a lesion of the female breast). Most eponymous terms other than those for units of measurement are capitalized.

HEDGING

Many careful researchers in biology have some degree of doubt about their observations and conclusions. To convey their uncertainty, they hedge—that is, they "arrange a way of escape from any position taken." In their articles they use such nouns as *view, supposition, idea, notion, speculation, conjecture, surmise, thought,* and even *guess;* such qualifying adverbs as *probably, possibly,* and *apparently;* and such verbs as *indicate, suggest, appear, seem, may,* and especially *might.*

When you think you must hedge—and at times disciplined hedging is necessary—select the word that precisely describes the situation. Do not overdo the hedge. The following sentence contains what may be regarded as a triple-barreled hedge:

> The fact that the active enzyme system is found only in the chlorophyllous plant *may* be *suggestive* of a *possible* function in the photosynthetic reactions.

The nearest approach to absolute certainty in scientific concept is expressed by the term *law of nature.* The law of gravitation is an example. At a somewhat lower level in the hierarchy of certainty is the *theory*, which is subject to revision as knowledge increases. A *theory* is a general principle offered to explain or predict a phenomenon, a verified hypothesis widely applicable; in a technical paper, use the term *theory* only in this restricted sense. A *hypothesis* is a provisional conjecture, a proposition assumed for argument or test, or a supposition leading to investigation or study.

SIMILE AND METAPHOR

If you use figures of speech make them appropriate and consistent. A simile explicitly compares one thing to something of a different kind, class, or quality; the comparison is usually illustrative and introduced by *like, as, as if,* or *as when.* "The water is as blue as the sky." Do not mix the figures: "Your contribution will seem like a drop in the bucket of this great bundle of red tape." In metaphor, a word or phrase denotes one kind of object or idea in place of another by suggesting a likeness or analogy between them: "The professor *punctured* my excuses with a question"; "A mad bull is a *demon of energy.*" Use metaphors sparingly, if at all, and avoid mixed comparisons that lead to absurdity:

> Already there are indications that astronautics is upsetting the familiar applecart in which for generations we have piled our most precious ideas and rationalizations which protect and comfort us in the midst of the sea of ignorance which is our true cosmic environment. What is more important is that the impact of astronautics is only beginning to be felt and that this influence will rapidly mushroom to almost infinite proportions.

EXAMPLES OF FAULTY WRITING

Below are examples of wordy or otherwise faulty writing and, opposite each, one or more corrections or suggestions for improvement. Each of the five examples and five corrections set in italics is from an article by Kesling (1958:274-276) that first appeared in *Turtox News.*

Wordy	*Concise*
Our research, designed to test the fatal effects of XXX on dogs, was carried out by intravenously introducing the drug. In the experiments, a relatively small quantity, 3 cubic centimeters, was administered to each animal. In each case, XXX proved to be fatal, all dogs expiring before a lapse of five minutes after the injection.	*The intravenous injection of only 3 cc of XXX kills a dog within five minutes.* Intravenous injection of 3 ml of XXX to each of x dogs killed the animals within 5 min.
A method, which was found to be expedient and not very difficult to accomplish and which possessed a high degree of accuracy in its results, was devised whereby	*An easy, accurate way to . . . .* I devised a simple, accurate method to . . . .
The quantitative findings reported by Smith were analyzed and seemed, according to our interpretation, to contain signifi-	*We think Smith's measurements are wrong because . . . .* We question Smith's measurements because . . . .

Wordy	*Concise*
cant inconsistencies. Our reasons for attaining this diverse opinion are	
Of the utmost importance is the need to examine quantitatively the various instars which have not reached maturity, in order to evaluate and determine the validity of the theory advocated by Przibram.	*To test Przibram's theory, all immature instars must be measured.* To test Przibram's hypothesis, measure all instars. Measurement of instars can be used to test Przibram's hypothesis.
One might well be censured for so tenaciously propounding this hypothesis in view of the weight of evidence to the contrary.	*I was wrong.*
a number of	few, many, several
an innumerable number of tiny veins	innumerable tiny veins
at the present moment (time)	now
bright green in color	bright green
by means of	by, with
conducted inoculation experiments on	inoculated
contemporaneous in age	contemporaneous
created the possibility	made possible
due to the fact that	because
during the time that	while
equally as well	equally well
fewer in number	fewer
for the reason that	because, since
from the standpoint of	according to
goes under the name of	is called
Growth accelerates, as can be seen from Table X (*or* Fig. X).	Growth accelerates (Table X) *or* (Fig. X). Table X (*or* Fig. X) shows that growth accelerates.
if conditions are such that	if
in all cases	always, invariably
in order to	to
in terms of	in
in the event that	if
in view of the fact that	since, because
it is often the case that	often
it is possible that the cause is	the cause may be

Wordy	*Concise*
it is this that	this
it would thus appear that	apparently
large numbers of	many
lenticular in character	lenticular
masses are of large size	masses are large
of such hardness that	so hard that
on the basis of	from, by, because
oval in shape *or* oval-shaped	oval
plants exhibited good growth	plants grew well
serves the function of being	is
species in which the hairs are lacking	species lacking hairs
subsequent to	after
the fish in question	this fish
the tests have not as yet	the tests have not
the treatment having been performed	after treatment
there can be little doubt that this is	this probably is
they are both alike	they are alike
throughout the entire area	throughout the area
throughout the whole of the experiment	throughout the experiment
two equal halves	halves
we will always have a miscellany of quality in terms of illustrations	the quality of illustrations will always vary
with reference to	about
As already stated	Omit such introductory phrases.
Concerning this matter it may be borne in mind that	
In this connection the statement may be made that	
It is interesting to note that	
It has long been known that	
It may be said that	
Typical results are shown	
With respect to the occurrence of these types, it has been found that	
As far as my own observations are concerned, they show	My observations show
As far as this fauna is concerned, it	This fauna is
As for the frog, they are	Frogs are

Wordy	*Concise*
It has not been possible to identify it with any of the described forms, and it seems to be so distinct that it is probable that additional examples could be recognized without difficulty.	I could not identify it, but it is so distinct that one may easily recognize additional specimens.

Nonsense	*Sense*
This book fills a much-needed gap	This book is much needed
What we need is a list of biologists broken down by specialization	What we need is a list of biologists classified by specialties
While flying over Fort Churchill in a Polar Cub, two foxes were seen in a highly abnormal condition	From a Polar Cub, flying over Fort Churchill, I saw two foxes in a highly abnormal condition
On November 2, 1957, a porcupine was brought to the laboratory by a wildlife biologist in a moribund condition	On 2 November 1957, a wildlife biologist brought a moribund porcupine to the laboratory

3. Mechanical Conventions

INTRODUCTION

Words committed to paper lack some of the important devices that help to give meaning to spoken words. In themselves, written words provide for no short pauses, no long pauses, no rising inflections, no change of pace. And so punctuation developed as a sign convention to do, or attempt to do, for written words what the human voice does for spoken words.

Science has employed other sign conventions—symbols, abbreviations, agreed-upon ways of expressing numbers. All have as their purpose more precise, more rapid, or easier communication. The most important of these conventions are discussed in this chapter.

PUNCTUATION

The following rules for punctuation are based on practices that have been widely accepted. But not all editors accept all these rules. The present tendency is to avoid "unnecessary" punctuation. A sensible policy for a confused writer unable to decide whether to insert a punctuation mark is to insert it. A copy editor in the journal office can delete two dozen unnecessary commas in less time than is required to write one letter to clear up confusion about the meaning of an underpunctuated sentence.

Punctuation, if properly used, signals the relationships among words or word groups. It must not be expected to do the work that logical word order should do. If you have trouble punctuating a sentence, examine its construction. Perhaps you should recast the sentence or divide it into two or more sentences.

PERIOD

The period has two main functions: (i) when used with a group of words, to indicate a full stop; (ii) when used with part of a word, to indicate abbreviation (see Chapter 12). It also has special functions (see "Spaced Periods or Ellipsis Marks" and "Raised Period," this chapter). With numerals it is used as a decimal point.

1) Use a period (or periods)
    a) after a declarative sentence:
        The titmouse is common in Illinois.
    b) after an imperative sentence:
        Filter the solution.
    c) with an abbreviation for the name of a state, month, day of the week, or a person's given name(s):
        N.C. Jan. Thurs. S. A. Forbes
    d) with an abbreviation in which omission of the period(s) might cause confusion:
        fig. ed. c.o.d. anon.
    e) with an abbreviation for a Latin term:
        e.g. i.e. no. sp.n. et al.
    f) with an abbreviation for each of many nontechnical words commonly abbreviated:
        Jr. Sr. Ave. St. B.C.
    g) at the end of a run-in sidehead (in some journals and books).
2) Place the period (special situations)
    a) inside the closing quotation mark in a sentence ending with a quoted word, even though the period is not part of the quotation.

b) inside the closing parenthesis or bracket when the parenthetical matter is an independent sentence.

The first rat died. (It had refused to eat.)

c) outside the closing parenthesis or bracket when the parenthetical matter is a dependent element at the end of a sentence.

The first rat died (the one that had refused to eat).

d) after ellipsis marks when the omitted material is at the end of a sentence.

3) Do not use a period

a) with a capital-letter abbreviation of the formal name of the United States or the Soviet Union, a United States government agency, a society, an international agency, or a compass direction:

USA	NIH	CBE	WHO	N
USSR	FDA	AAAS	UNESCO	SE

b) with the symbol for a chemical element or the letters of a contraction for a chemical, biological, or medical expression:

Ar	ACTH	CNS
B	DNA	EEG
Cl	tRNA	RBC

c) with a lowercase contraction or abbreviation (except Latin) commonly acceptable in scientific or technical writing:

concn	diam	exp	log
sin	satd	mol	mol wt

d) with an abbreviation for a unit of measure:

Å cm °C mg g nm

e) after a period that follows an abbreviation at the end of a sentence.

f) after a title, head, subhead, equation, or formula standing separate from the text.

g) after an entry in a table (unless the entry is, or ends with, an abbreviation that requires a period).

h) after an item in a list (unless the item is a complete sentence, completes a sentence, as in this item *h*, or ends with an abbreviation that requires a period).

SPACED PERIODS OR ELLIPSIS MARKS

1) Use three spaced periods (ellipsis marks) to indicate omission of a word or group of words within quoted material. Leave a space before and after the ellipsis marks: "Mary had a . . . lamb." To indicate that words have been omitted from the end of a sentence within quoted material, place the ellipsis marks before the period . . . .To indicate the omission of one or more paragraphs from quoted material, use an entire line of spaced periods.
2) Do not use ellipsis marks if you have given notice to the reader in some other way that you have omitted words.

   Smith (1962) characterized the outbreak as "the heaviest infestation" he had seen in 1960.

   The context gives notice that some of Smith's words have been omitted.

   Morgan (1928) stated that a science writer "must consider whether his meaning will be clear to students of literature."

   The lowercase *m* in *must* gives notice that the first part of the sentence has been omitted. If "to students of literature" were to be omitted from the sentence, candor might dictate that the example should end thus:

   will be clear . . . ."

RAISED PERIOD

1) Use a raised (centered) period
   a) to indicate multiplication if space does not permit use of the multiplication sign or if closed-up or thin-spaced symbols are unsatisfactory:

      $k \cdot g(a + 2)$ *instead of* $k \times g(a + 2)$

   b) for water of hydration in a chemical formula:

      $Na_2B_4O_7 \cdot 10H_2O$

   c) for associating base pairs of nucleotides, for example guanine and cystosine:

      $G \cdot C$

   d) for a chemical bond if the standard bond sign occupies too much space:

      $R \cdot CH_3$ *instead of* $R—CH_3$

   e) for certain genetic expressions:

      $AA \cdot AB \cdot BB$

f) for an ellipsis in mathematical matter (to align with a sign of operation):

$x_1 + x_2 + \cdot \cdot \cdot x_n$ $x_1, x_2, \cdot \cdot \cdot, x_n$

g) to indicate multiplication when necessary to show the product of two or more units of measure. For example, the unit of electric charge, the coulomb (C), is the product of the units of current (ampere, A) and time (second, s):

$1 \text{ C} = 1 \text{ A} \cdot \text{s}$

Similarly, the unit for work, energy, and quantity of heat, the joule (J), is the product of the units for force (newton, N) and length (meter, m).

$1 \text{ J} = 1 \text{ N} \cdot \text{m}$

2) In preparing the typescript, do not space before or after a raised period in chemical or mathematical matter except when ellipsis is indicated. The editor of your journal, or an assistant, may instruct the printer to center the period between the nearest characters, with a small amount of space (hair space, thin space) before and after it.

COMMA

See also page 41

The comma separates elements of a sentence and helps to group words, phrases, and clauses for clarity and for ease and speed in reading. Placed at the end of a long introductory phrase or clause, it helps locate the subject, which usually follows closely.

1) Use a comma

a) to separate two independent clauses joined by a coordinating conjunction (*and, but, neither, nor, or*), except as in 3*a* next below. See also 1*b* under "Semicolon," this chapter.

b) to set off an introductory clause begun with a subordinating conjunction (*if, although, since, when, where, while, because*), except as in 3*b* next below.

c) to set off an introductory phrase (In the dark of the moon) except as in 3*b* next below. Even with some very short introductory phrases a comma is necessary to prevent misreading:

In all, eight experiments were performed.

d) to separate a nonrestrictive (nondefining) clause or phrase from the rest of the sentence (a nonrestrictive element gives information other than that essential for identification of its subject; see "That and Which," Chapter 2).

e) to separate a nonrestrictive appositive from the rest of the sentence:

Raymond Turner, a mammalogist, described the species.

f) to separate the elements (words, phrases, or clauses) of a simple series of more than two. (A comma precedes the *and* or *or*):

The tomatoes, beans, and peppers were planted in April.

The weather was not favorable in the spring, in midsummer, or even in the early fall.

The tomatoes wilted, the beans died in August, and the peppers bore no fruit.

If any of the elements contain internal punctuation, separate them with semicolons.

g) to set off a conjunctive adverb (*therefore, thus, still, however, accordingly, moreover, nevertheless, consequently*) or a transitional phrase (*on the contrary, on the other hand, in fact, after all, in the first place*) that introduces a distinct break in continuity of thought. A word or phrase of this kind that introduces a clause should not be preceded by a comma but by a period or a semicolon.

h) to introduce a short quotation (a colon is preferable for a long one).

i) to set off contrasted expressions:

It is orange, not red.

The greater the risks, the more gratifying will be the result if the flight is successful.

j) to set off words, phrases, or clauses placed out of their natural position for emphasis or clarity:

Keys provide, except in the most specialized works, a useful means of identification.

k) to separate adjacent sets of numbers:

In 1935, 100 experiments were completed.

l) to group digits in threes in most numbers of 1,000 or more:

1,001 18,734 1,034,569

For exceptions to the general rule, see 3*d* below. Some journals use a space instead of a comma; this usage has international recognition.

2) Place the comma
   a) inside the closing quotation mark when a sentence continues beyond the end of the quoted matter, even when the comma is not part of the quotation.
   b) after a period that follows an abbreviation if the sentence requires a comma (do not expect the period to do its own work and substitute for the comma also).
   c) outside a closing parenthesis or bracket.
3) Do not use a comma
   a) between two independent clauses joined by a coordinating conjunction if the clauses are not complex or unusually long and if absence of the comma would not result in ambiguity.
   b) after a short introductory phrase or clause if the comma does not contribute to clarity or speed of reading. (A current tendency is to omit the comma.)
   c) before or after a restrictive (defining) appositive:

      The species *Bombyx mori* was described later.

   d) between digits in a page number, an address, or a year number:

      page 6984 1933 Glenwood Avenue 1066 A.D.

   e) after a title, head, subhead, equation, or formula standing separate from the text.
   f) to separate subject and predicate, except when they are separated by phrases or clauses requiring balancing commas. Punctuate a sentence containing a noun clause or a noun phrase as if the clause or phrase were a single word. In the first example below, a noun clause is the object of a verb. No comma separates verb from object or verb from subject except in the third example, in which a prepositional phrase intervenes.

      He said *that the bird was a flicker.*

Where the plant grew was fertile ground.
Where the plant grew, at the bottom of a narrow ravine, was fertile ground.

SEMICOLON

See also page 41

The semicolon is a mark of coordination and therefore should not be used immediately before or after a dependent clause.

1) Use a semicolon (or semicolons)
   a) to separate coordinate clauses not joined by a conjunction:

      I came; I saw; I conquered.

   b) to separate coordinate clauses joined by a conjunctive adverb:

      No physician was available; however, the patient recovered.

   c) to separate the elements of a complex series, that is, elements containing internal punctuation:

      The tomatoes wilted; the beans, which had been planted early, died in August; and the peppers, a late variety, bore no fruit.

2) Place the semicolon outside a closing quotation mark, parenthesis, or bracket.
3) Do not use a semicolon after a title, head, subhead, equation, or formula standing separate from the text.

COLON

1) Use a colon
   a) to introduce a long quotation (a comma is sufficient for a short one).
   b) to introduce a list or enumeration not immediately preceded by a verb or preposition.
   c) to emphasize a close relationship in thought between two independent clauses.
   d) to separate a complete clause from a following illustrative word, phrase, or clause.
   e) to separate the parts of a ratio (equal space before and after colon).
   f) to separate a volume or serial number from page number(s) in a list of references (no space before or after colon):

      Syst. Zool. 3:38–45   J. Hered. 49(3):285–293

  g) to separate year and page number(s) when page references are given in author-date citations in text:

     Riker 1946:954   Scott (1965:234–237)

2) Place the colon outside a closing quotation mark, parenthesis, or bracket.
3) Do not use a colon after a title, head, subhead, equation, or formula standing separate from the text.

QUESTION MARK

1) Use a question mark at the end of a direct question, even if the question is presented in declarative form.
2) Do not use a question mark after an indirect question.
3) Place the question mark inside a closing quotation mark if it is part of the quotation, outside if it is not.

EXCLAMATION MARK

The exclamation mark is rarely justified in scientific writing except as a factorial symbol in mathematics:

$(x - 2)/6!$

In early taxonomic reports, the exclamation mark was used in place of *sic* and as a mark of affirmation.

DASHES

Dashes of three different lengths are common in printed matter: the em dash (in type of any size, as long as the type is high), the en dash (half the length of the em dash), and the 3-em dash. In your typescript, use hyphens to indicate dashes.

1) Use two hyphens together (the editor will mark them for an em dash)
   a) to indicate an abrupt break in thought (use sparingly).
   b) to isolate parenthetical matter as parentheses are used.
   c) within brackets within parentheses for a third level of interpolation:

      (The house sparrow [common in bushes—shun this cumbersome construction—as well as in trees] is a bird.)

2) Use a hyphen (the editor will mark it for an en dash) to indicate range:

   10–20 mm   pages 6–10   33.9–14

Neither a minus sign nor the word *from* should be used with an en dash:

−4 to −6°C (*not* −4 – −6°C)
from page 6 to 10 (*not* from page 6–10)

3) Many journals use a 3-em dash in a bibliographic entry rather than repeat the name(s) of the author(s) of a previous entry. Do not use this dash in your typescript; repeat the name(s) of the author(s). See page 158.

PARENTHESES

See also page 41

1) Use parentheses
   a) to enclose comment or explanation that is structurally independent of the sentence (parentheses indicate a greater independence than dashes or commas).
   b) to group mathematical expressions.
   c) to label enumerations included within a paragraph:

   The four steps were (i) . . . , (ii) . . . , (iii) . . . , (iv) . . . .

   But do not label enumerations unless labels are necessary for ease and speed of reading.
2) Avoid use of parentheses within parentheses: (. . . (. . .) . . .). See "Brackets," below, and "Dashes," above.
3) Use a closing parenthesis to set off the numeral or letter of an enumerated phrase, paragraph, or other element that begins a line, as on this page.

BRACKETS

1) Use brackets
   a) to enclose any matter, including bibliographic details, you have inserted in a quotation:

   "A major concern [for NSF] must be technology assessment."

   "The average seeding effect in the entire region [comprising 100,000 km^2] is a 21 per cent loss of rain."

   "The results of an analysis by Neyman, Scott, and Smith [Science 163:1445–1449] of one carefully conducted experiment were released to the press."

   b) to enclose parenthetical material you insert within parentheses.

c) to enclose symbols representing absolute values.

2) Do not use brackets to enclose parenthetical material that is more appropriately enclosed by commas or parentheses.

APOSTROPHE

One of the chief functions of the apostrophe is to show or help show possession in nouns. Whether an inanimate object can possess something is a philosophical rather than a grammatical matter. The biologist who objects to "the leaf's color" may, instead, write "the color of the leaf" or even "leaf color."

1) Use an apostrophe
    a) and *s* to form the possessive of a singular noun (some exceptions) or an indefinite pronoun, even if it ends in *s* or another sibilant:

    man's deer's Mendel's ibis's fox's one's

    Notable exceptions to this rule are a few nouns, most of them proper and of more than one syllable, that end in a sibilant. If the addition of an apostrophe and *s* (creating a new syllable) would result in a word that is difficult or awkward to pronounce, the tendency is to form the possessive without the final *s*. Some authors would write "Yates's meteorological studies" and "for conscience's sake"; perhaps an equal number would drop the final *s*. Most authors would write and most editors accept the following examples:

Charles's law	Archimedes' principle
Berlioz's operas	Euripides' plays
Marx's followers	Jesus' disciples

    If the final *s* or its equivalent in a noun is silent, as in many French names, an apostrophe and *s* are added to form the possessive:

    Descartes's essays Agassiz's lectures

    The apostrophe is added to the final element of a compound:

    someone's pen someone else's proposal

    b) and *s* to form the possessive of a plural noun not ending in a sibilant:

men's children's deer's addenda's
media's brothers-in-law's

c) alone (not followed by an *s*) to form the possessive of a plural noun ending in a sibilant:

eyewitnesses' accounts old wives' tales
the Adamses' papers scientists' opinions

d) and *s* to form the plural of a letter, a numeral, a symbol, a word used as a word, and certain abbreviations that retain periods:

i's A's B's 7's 1960's ♂'s
the *which*'s and *that*'s D.Sc.'s I.Q.'s

e) to indicate the omission of a letter or letters in some common contractions (most of them undesirable in scientific writing):

ass'n att'y cont'd rec'd
you're he's she's it's

2) Do not use an apostrophe

a) with a personal pronoun in the possessive case:

her hers their theirs its

b) with a possessive *s* in the first element of a well-established geographic name in the United States (a British geographic name is likely to retain the apostrophe):

Buzzards Bay Pikes Peak Woods Hole
Land's End (England) St. John's (Newfoundland)

c) in the name of an organization in which the qualifying term is treated as an adjective rather than as a possessive noun:

Authors League of America (*but* Showmen's League of America)

Teachers College (*but* Woman's Christian Temperance Union)

QUOTATION MARKS

1) Use double quotation marks to enclose
   a) a direct, primary quotation.
   b) a tertiary quotation (a quotation within a quotation within a quotation).

    - c) the title of an article, the title of a chapter or other part of a book, or the title of a series, except when the title is in a bibliographic list.
    - d) a new technical term, or an old term applied in a new or unusual sense, unless the journal style calls for italicizing such a term.
2) Use single quotation marks to enclose a secondary quotation (quoted matter within a quotation).
3) If a quotation extends over more than one paragraph, begin each paragraph with a quotation mark; close the quotation by a quotation mark at the end of the last paragraph only. (A copy editor may instruct the printer to set your long quotations in smaller type or narrower measure, or both, and thus eliminate the need for quotation marks.)
4) Observe the following relationships to other punctuation marks:
    - a) Place a comma or a period inside the closing quotation mark even if it is not part of the quotation.
    - b) Place a semicolon or a colon outside the closing quotation mark.
    - c) Place any punctuation mark other than those named above inside the closing quotation mark if it is part of the quotation, outside if it is not.
5) Do not use a quotation mark with an indirect quotation.

HYPHEN

1) Use a hyphen
    - a) between the numerator and the denominator of a spelled-out fraction unless either is already hyphenated:

      one-third five thirty-seconds thirty-two hundredths

    - b) to indicate range (a copy editor will mark the hyphen for an en dash; see "Dashes," this chapter).
    - c) to indicate the location of the important bonds in chemical or molecular formulas: $R—CH_3$ or $—SH$.
    - d) in other situations as discussed under "Compound Terms" and "Derivatives," this chapter.
2) Although you are advised in this manual not to divide any word at the end of a line in your typescript, you will

eventually need to know where hyphens should be placed in divided words; you may find several divided words in the galley proof you receive from the printer. See "Checking Word Division," Chapter 9.

SLANT LINE

Because the slant line (/), variously called *solidus, virgule, diagonal, stroke, slash,* and *shilling mark,* is a mathematical sign of operation (meaning *divided by*) as well as a substitute for *per* (a preposition meaning *for each,* as in "50 miles per hour"), it must be used with care.

1) Use a slant line
   a) as a mathematical sign for division ($3/4 = \frac{3}{4}$).
   b) to show rates (5 m/s) or concentrations (20 mol/liter). Observe the rules of mathematics if more than one slant line or *per* occurs in an expression; see 2*b* below.
   c) to indicate division when necessary to show the quotient of two or more units of measure.

velocity, meter per second	m/s
force, kilogram meter per second squared (≡ newton)	$kg \cdot m/s^2$
illumination, lumen per square meter (≡ lux)	lm/m^2
pressure, newton per square meter	N/m^2
viscosity, newton-second per square meter	$N \cdot s/m^2$

2) Do not use a slant line
   a) to express a ratio, as in a description of a buffer solution.
   b) as shorthand for *per* if more than one occurs in a measurement. The expression "1.5 $pCi/km^2/yr$" is mathematically ambiguous. To abbreviate with mathematical correctness the measurement given in the sentence "The strontium fallout was 1.5 picocuries per square kilometer per year," use one of the following forms:

$1.5\ pCi \cdot km^{-2} \cdot yr^{-1}$

$1.5\ pCi/km^2 \cdot yr$

$1.5\ pCi/km^2$ per yr

$1.5\ pCi/(km^2 \cdot yr)$

SERIES AND ENUMERATIONS

Elements of a series may range from single words to complex enumerations, each one of which may require a separate sentence or paragraph.

However simple or complex, the elements (usually three and in a sentence) must have parallel construction. The following sentence is not properly constructed; the person who wrote it assumed incorrectly that the last element was part of a series.

> The mixture was heated, shaken, centrifuged, and the supernatant fluid frozen.

The sentence can be corrected by making the last element a coordinate clause:

> The mixture was heated, shaken, and centrifuged; the supernatant fluid was frozen.

The elements of a series may be kept in order by one or more of several devices: (i) punctuation; (ii) such indicative words as *and, then, when, afterward,* and *finally;* (iii) numerals, letters, or both.

Suggestions for punctuating series at various levels of complexity follow.

1) Use commas to separate the elements of a simple series (the lowest level of complexity):

   > The mixture was heated, shaken, and centrifuged.
   >
   > The mixture was heated at 40°C, shaken at 30 cycles per second, and centrifuged at 18,000*g*.

2) Use semicolons to punctuate a series at the second level of complexity, as in a sentence having clauses that contain internal punctuation:

   > The mixture was heated, shaken, and centrifuged; the pellet was discarded; and the supernatant fluid was quick-frozen and stored for 3 days at −10°C.

3) In punctuating a series at the third level of complexity, you may enumerate the main elements (which may be either independent clauses or sentences) with lowercase roman numerals, arabic numerals, or lowercase letters (italic or roman) in parentheses, in accordance with the style of the journal for which your article is designed.

   (i), (ii), (iii)   (1), (2), (3)
   (a), (b), (c)   (*a*), (*b*), (*c*)

Use semicolons and commas for internal punctuation, as suggested above and in "Semicolon" and "Comma," this chapter. The use of numerals or letters in complex series does not preclude their use in simple series if they are deemed necessary for clarity or for ease or speed of reading.

4) In punctuating complex series in which paragraphs are the elements, begin each paragraph with an arabic numeral and a closing parenthesis:

   1) 2) 3)

DIACRITICAL MARKS

Several common diacritical marks (diacritics) that distinguish the pronunciation of certain letters in some European languages are shown in Table 1; in the third column are a few words that have been transliterated from a language not using the Latin alphabet.

Table 1. Diacritical marks used in European languages. In the examples below, any word from a language not based on the Latin alphabet has been transliterated.

Mark	Name	Example
°	circled *or* ringed	Ångstrom
´	acute accent	beauté
`	grave accent	le congrès
¸	cedilla	garçon
˛	inverted cedilla	Dąbrowa
^	circumflex	bâtir
ˇ	inverted circumflex	Čechoslovaca
¨	dieresis	naïvement
˘	kratkaya *or* breve	Omskiĭ
¯	macron	Kyūshū
ʼ	soft sign	Krasil'nikov
/	slash *or* stød	København
ˊ	stroke	społka
˙	superior dot	Skarżysko
˜	tilde	Español
¨	umlaut	für Anfänger

Ink in on your typescript any required diacritical mark not easily available on a typewriter. Identify any mark that might be misinterpreted; write its name, with a circle around it, in the nearest margin.

A foreign word accepted into English may or may not lose its diacritic; *facade* has lost its cedilla, but *garçon* retains it. The spelling of some adopted words has been adjusted to reflect the accepted pronunciations: *canyon* for *cañon.*

If a foreign place name containing a diacritic has an English equivalent, use it: *Cologne* (not *Köln*); *Nuremberg* (not *Nürnberg*).

Because few printers have type for all the characters with diacritics, you or your editor may need to supply substitutes. For the umlaut in a German word, substitute the plain letter followed by *e*: write *ueber* and *Blaetter* for *über* and *Blätter.*

In Scandinavian languages, the ringed *Å* and *å* were once *Aa* and *aa* and are sometimes so spelled today. An umlaut over an *o* is sometimes substituted for the stod, but in a proper name it is often omitted; *Sørensen* may be spelled *Sörensen* but more often it is spelled *Sorensen.*

Some of the diacritics require special type characters, which can usually be procured only after a lengthy wait.

ITALICS AND CAPITALS

The common usages of italic type and capital letters are outlined in "Typographical Conventions," Chapter 8. The usages peculiar to certain areas of biology are discussed in "Typography," a subsection of "Botany, Zoology, and Microbiology," Chapter 4.

COMPOUND TERMS

A compound term is a combination of two or more words that through use together in a certain context have acquired a special meaning:

bluebird (a bird of the genus *Sialia*)

The words *blue bird* written separately have no special meaning. They might refer to a blue jay, an indigo bunting, or a kingfisher.

Not all compounds are written as one word. Some are written open (wood duck), some solid (jellyfish), and some hyphenated (half-cell). A few compounds that would otherwise be written solid are hyphenated to prevent a confusing sequence of letters or a confusion of ideas (freeze-dry, red-ear sunfish).

Several scientific societies have published lists of common or vernacular names, many of which are compounds. Follow the spelling in the latest editions of these lists unless you have a good reason for doing otherwise.

The Entomological Society of America (Blickenstaff 1970) observes the following practices in writing insect names that are compounds: if the base word, a group word, is taxonomically correct, it is written as a separate word (*honey bee, house fly, bed bug*); otherwise it is written solid with the modifier that immediately precedes it (*butterfly, mealybug*). A hyphen is used between elements of a compound if its absence would leave the meaning obscure: *black pine-leaf scale*.

Detailed information on compound words may be found in *Webster's Third New International Dictionary* (1961) under "The Writing of Compounds," pages 30a-31a in the front matter.

A few generalizations about the writing of compounds are given below:

1) A compound derived from two or more nouns is usually written open if the elements are accented equally (*buffalo fish, oak wilt, subject matter*), written solid when one of the elements has lost its accent (*northwest, pineapple, paperback*), and hyphenated when one or both elements are terms of measurement (*gram-centimeter, light-year,* but *gram atom, gram molecule*).
2) A compound in which the second element (noun or pronoun) is the direct object of a verb is usually written solid (*killjoy, lockjaw, carryall*) unless confusing combinations of letters result, when a hyphen is indicated (*cure-all*). A compound consisting solely of verbs is usually hyphenated (*has-been, might-have-been*).

3) A phrase containing a participle (present or past) or an adjective may be hyphenated as a compound when it precedes the word modified and written without a hyphen when it follows:

A well-known method was followed.
The method followed was well known.
He began the small-bird study in 1969.
He began the study of small birds in 1969.

4) A compound modifier containing a number is usually hyphenated:

two-thirds majority
a can of 10-ml pipettes
two 30-mm rods
a 1-minute exposure

5) An open compound noun that is well established and widely known in its field is usually not hyphenated even when it functions as an adjective preceding the word it modifies (in this category are names of many chemicals, diseases, animals, insects, and plants):

hydrogen bromide fumes
blue jay migration
stem rust control
chinch bug damage

6) A two-word modifier containing an adverb ending in *ly* is not hyphenated:

a naturally occurring substance
a carefully preserved specimen

7) Many compounds derived from an adverb and a verb, or from a preposition and a noun, are written solid, particularly those that might cause confusion if written open:

underdeveloped
undercurrent
downstream
feedback
input
uphill
everblooming
afterpotential
overdosage

DERIVATIVES

A word formed from a base element and one of many prefixes (*anti, non, pre, re, semi, un*) or suffixes (*ful, ize, less, like*) usually is written solid. This type of word is discussed under

"Derivatives" on pages 23a–25a of the front matter of *Webster's Third New International Dictionary* (1961).

A few exceptions to the general practice follow: (i) a word that if written solid might have a confusing juxtaposition of letters (*anti-icer, intra-abdominal, intra-atomic, semi-infinite, semi-ionic*); (ii) a word in which the base element begins with a capital letter (*mid-March, trans-Ural*)—but *transatlantic* and *Precambrian;* (iii) a word containing a prefix that governs two or more words (*pre-Ice Age*)—the editor may mark the hyphen for an en dash; (iv) a word containing a prefix that, if written solid with the base element, would form a word easily confused with another (*re-strain, restrain; un-ionized, unionized*); (v) a word containing a suffix that with the base element forms a succession of three identical letters (*cell-like, hull-less*).

ABBREVIATIONS AND SYMBOLS

See also Chapter 12

An *abbreviation* consists of one or more letters (rarely more than four) to which a word or phrase has been reduced by the omission of words or letters (vol for volume). The term *symbol,* as used here, may be applied to an abbreviation (DDT, m, g), an arbitrarily designated letter of the alphabet, or a conventional sign (♀). An *acronym,* a word formed from the initials of successive parts of a compound term, may be considered both abbreviation and symbol (UNESCO).

IN TEXT MATTER

Abbreviations and symbols save space and, when used in text with discretion, simplify complex expressions and increase the speed of reading. If overused, they present a formidable appearance to a page and slow down the rate of reading; they may even make an article unintelligible.

In your technical writing, you may make unlimited use of symbols that are standard for units of measure in many branches of science. But use abbreviations with discretion. Base your decisions about abbreviations on your considered judgment of the reader you expect to reach and of the way you can most efficiently give him the results of your research. Decide which and how many abbreviations you think will have meaning for him as he reads your article and which ones you should define. If you are writing for readers in a highly specialized field, more abbreviations peculiar to that field are permissible than if you are writing for readers in another field or fields. You may abbreviate more freely in tables, equations, and formulas than in text.

If you coin an abbreviation or use one that might not be familiar to a potential reader, define it precisely the first time it appears in your article. When in doubt, spell out. If, in spelling out certain words, you do not conform to the style of the journal for which you are writing, the words can easily be abbreviated in the editorial office, but if you use abbreviations that are ambiguous you are likely to inconvenience the editor or confuse your readers.

Do not succumb to "abbreviation disease," the habit of repeating an abbreviation where a pronoun, a demonstrative adjective, or a short reference phrase would result in less monotony with no loss of clarity. For example, if you are writing about adenosine triphosphate (ATP), refer to it occasonally by a term such as *it, this compound,* or *the phosphate,* instead of repeating the abbreviation monotonously.

Do not start a sentence with an abbreviation or symbol if you can avoid it.

IN TITLE, ABSTRACT, TRANSLATION

Do not abbreviate in the title or abstract of a paper. Use only common, universally understood abbreviations in translations and in computer retrieval operations; otherwise misunderstanding might result.

IN FIGURES AND TABLES

You may use the common abbreviations freely in tables and figures; others you may use if you define them in footnotes to tables or in legends of figures.

FOR GEOGRAPHIC AND GEOLOGIC NAMES

You may abbreviate a state, provincial, or district name preceded by the name of a city or town:

Cambridge, Mass.	Washington, D.C.
Santa Anita, D.F.	Moose Jaw, Sask.

Although you should not abbreviate a state, province, or district name standing alone in text, you may abbreviate it in tabular matter.

Follow similar practices for the abbreviations of most countries. The abbreviations USA and USSR you may use freely.

Do not abbreviate an English translation of a geographic name of foreign origin.

Do not abbreviate the name of a division of the earth's surface, a continent, a region, a mountain or mountain range, or an ocean, sea, lake, or river:

Arctic Circle	Africa	Sahara
South Pole	South America	Middle West
Mount Killington	Pacific Ocean	Lake Michigan
the Himalayas	Red Sea	Hudson River

To indicate stratigraphic and time divisions on maps, use the symbols adopted by the United States Geological Survey (1958) and shown in Table 5, Chapter 4.

FOR NAMES OF CHEMICALS AND DRUGS

If you wish to use an abbreviation for the name of a chemical or drug, spell out the name the first time it appears in the text and follow it with the abbreviation in parentheses. Do not abbreviate the name of an enzyme without defining it on its first appearance in the text.

FOR NAMES OF UNITS OF MEASURE

Abbreviate a term of measurement in text matter only if it is preceded by a number; use the same abbreviation for plural as for singular. (Some journals spell out a short word for a unit of measure even if it follows a number.)

Spell out the name of a unit of measure that follows a spelled-out number, as at the start of a sentence:

Ten milligrams is the lethal dose.

Use the decimal system for units of concentration:

0.1M or 0.1 mol/liter or 10^3 mol/m^3 (not M/10)

Conventional signs and symbols are permitted in the text with units of measure; thus, the slant line (/) can substitute for *per* (see "Slant Line," this chapter) and % with an arabic numeral for *percent*. Do not use such ambiguous terms as "20 milligrams percent" (20 mg %). Use instead, as appropriate,

20 mg/100 ml   20 mg/100 mg   20 mg/100 g

International standards being developed recommend that the denominator in such expressions be changed to one of the base units of the Système International d'Unités (SI). The above terms would then become

0.2 mg/ml   0.2 mg/mg   0.2 mg/g

or, preferably,

0.2 kg/m^3 200 g/kg   200 mg/kg

FOR SCIENTIFIC NAMES

See also page 59

Spell out the scientific name of an organism in the title or abstract of a paper. Spell out a generic name when it is used without a specific or varietal name. Spell it out the first time it appears in a paper in combination with a specific or varietal name; thereafter you may abbreviate it to the first letter unless omission of the full name might result in confusion or misunderstanding, as when the names of two genera under discussion begin with the same letter.

For the abbreviation that may follow the proposed name in the description of a new genus, species, or variety, as in

Scirpus heterophyllus sp.n.   *Alloperla banksi* n.sp.

the Latin form is preferred in botanical journals, the English form in most other journals:

gen.n. *(genus novum)*	n.gen. (new genus)
sp.n. *(species nova)*	n.sp. (new species)
var.n *(varietas nova)*	n.var. (new variety)

Latin terms or their abbreviations may be employed for designating the status of scientific names. In the following examples, both singular and plural forms of the terms are given:

nom. cons.	*nomen conservandum*	*nomina conservanda*
nom. illeg.	*nomen illegitimum*	*nomina illegitima*
nom. nud.	*nomen nudum*	*nomina nuda*

IN SPECIALIZED FIELDS

Abbreviations and symbols approved for use in several specialized fields of biology are available in publications of national and international societies and organizations. Many of the abbreviations can be found in Chapter 12 of this manual and some in unabridged and specialized dictionaries. Several publications containing approved abbreviations are listed in Chapter 13.

WRITING ABBREVIATIONS

See also page 28 and Chapter 12

Do not letterspace the capital-letter abbreviation of a chemical expression, the name of an organization or a governmental group, the name of a time zone, etc.:

ACTH *for* adrenocorticotropic hormone
AIBS *for* American Institute of Biological Sciences
NIH *for* National Institutes of Health
EST *for* Eastern Standard Time

Space between the parts of a lowercase abbreviation of a compound term only if no period is between them:

mol wt   sp gr   et al.
e.g.   sp.n.   o.d.

Lowercase abbreviations of many compound terms are written without periods and without spaces between the parts (see Chapter 12):

bp   dpm   emf   ppm   rem

REPORTING NUMBERS

In reporting a decimal number, retain no more digits to the right of the decimal point than the precision of your experimental method warrants.

For “rounding” a decimal number in which three digits to the right of the decimal point are to be retained, follow this procedure:

1) If the digit to the right of the third digit is less than 5, leave the third digit unchanged:

   0.1282 rounds to 0.128.

2) If the digit to the right of the third digit is greater than 5, increase the third digit by 1:

   0.1286 rounds to 0.129.

3) If the digit to the right of the third digit is 5,
   a) and there is no nonzero digit to the right of the 5
      i) and the third digit is even, leave the third digit unchanged:

         0.1285 rounds to 0.128;
         0.12850 rounds to 0.128

      ii) and the third digit is odd, increase the third digit by 1:

         0.1275 rounds to 0.128;
         0.12750 rounds to 0.128

   b) and there is at least one nonzero digit to the right of the 5, increase the third digit by 1:

      0.12851 rounds to 0.129;
      0.12751 rounds to 0.128.

Follow a similar procedure when more or fewer than three digits to the right of the decimal point are to be retained.

For “rounding” an inconveniently large number, follow a procedure similar to that described for “rounding” decimal numbers. The number 2,645,381, for example, can be expressed as 2.6 millions.

WRITING NUMBERS

Unless the journal for which your article is designed has contrary instructions, observe the following rules for the writing of numbers in running text:

1) Use a numeral or numerals
   a) for expressing any number that immediately precedes a standard unit of measure or its abbreviation:

      1 gram 3 g 18 mm 300 m^2 3 hours

   b) for a date, an expression of time, a page number, a percentage, a decimal quantity, or a numerical designation:

      7 January 1971 *or* 7 Jan. 1971 the time is 0815
      page 1079 27 percent *or* 27% 37.6 g
      a magnification of 50

   c) for a number implying arithmetical manipulation:

      18 multiplied by 2 a factor of 2

   d) for numbers grouped for comparison or having statistical implications.

2) In most situations not mentioned above, use words for numbers one through nine and numerals for larger numbers:

   nine rabbits two dogs 14 parts 29 trees

   In a series containing some numbers of 10 or more and some less than 10, use numerals for all (in the example below, the series is trees):

   The 7 apple trees, 9 peach trees, and 20 plum trees were given six applications of dust.

3) Treat ordinal numbers as you would cardinal numbers:

   third fourth 33rd 54th

4) In writing a large number ending in several zeros, either substitute a word for part of the number or add an appropriate prefix to a basic unit of measurement:

   1.6 millions (*not* 1,600,000)
   23 μg (*not* 0.000 023 g)

5) Do not begin a sentence with a numeral; either spell out the numeral, reword the sentence, or end the preceding sentence with a semicolon.

REPORTING TIME

Two time systems are in common use throughout the world. In one, the hours of the day (the period of the earth's rotation on its axis) are numbered consecutively, 1 through 24. In the other, they are divided into two periods of 12 hours each, the first numbered 1 through 12 a.m. (before noon) and the second 1 through 12 p.m. (after noon).

Scientists should adopt the 24-hour time system, which is indicated by four digits—the first two for hours and the last two for minutes. The day begins at midnight, denoted 0000, and the last minute of the day is 2359. Thus, 0830 is the same as 8:30 a.m., 1230 the same as 12:30 p.m., and 2315 the same as 11:15 p.m. The notation *2400 of 10 June* designates the same instant of time as *0000 of 11 June.*

The 12-hour a.m. and p.m. time system sometimes leads to confusion. The terms *12 a.m.* or *12 p.m.* for noon or midnight are ambiguous. The term *midnight of 10 June* is also ambiguous, since it could refer either to midnight of 9–10 June or to midnight of 10–11 June.

METRIC AND DECIMAL SYSTEMS

The metric system for measures and weights is recommended in scientific writing because of its worldwide acceptance. Metric equivalents of weights and measures commonly used in the United States are given in Table 2. In accordance with action taken by the 12th General Assembly of the International Union of Biological Sciences at Rome, 12 to 14 April 1955, the decimal system rather than fractions should be used in scientific publications.

Although there are several metric systems of measure, including the centimeter-gram-second system and the meter-kilogram-second system, these systems are gradually being replaced by a modernized metric system, the Système International d'Unités (SI). The new system provides unambiguous symbols, standard in all languages, for units of measure. Adoption of the system is advocated by many scientists.

The SI system is based on six base units and two supplementary units. The base units are as follows:

length	meter (m)
mass	kilogram (kg)
time	second (s)
current	ampere (A)
thermodynamic temperature	kelvin (K)
luminous intensity	candela (cd)

Table 2. Units of measurement and weight commonly used in the United States and their metric equivalents.

Common	Metric	Common	Metric
inch	2.54 cm	pint, US liquid (16 oz)	0.473 liter
foot	30.48 cm	quart	
yard	0.914 m	US liquid (32 oz)	0.946 liter
fathom (2 yd)	1.829 m	US dry (2 pt)	1.101 liter
rod (5½ yd)	5.029 m	imperial (40 oz)	1.136 liter
furlong (220 yd)	201.16 m	gallon	
mile		US (4 qt)	3.785 liter
statute (1,760 yd)	1.609 km	imperial	4.546 liter
nautical (2,026 yd)	1.854 km	peck, dry	
knot	1.854 km/h	US (8 qt)	8.809 liter
square inch	6.452 cm^2	imperial	9.092 liter
square foot	0.092 m^2	bushel, dry	
square yard	0.836 m^2	US (4 pk)	35.24 liter
square rod	25.29 m^2	imperial	36.37 liter
square mile (640 acres)	2.59 km^2	pound	
acre	40.468 ares	avdp (16 dr)	453.592 g
cubic inch	16.387 cm^3	troy (12 oz)	373.24 g
cubic foot (1,728 in^3)	0.028 m^3	ounce	
cubic yard (27 ft^3)	0.7646 m^3	avdp (16 dr)	28.35 g
board foot (144 in^3)	0.0025 m^3	troy (480 gr)	31.103 g
cord (128 ft^3)	3.625 m^3	dram, avdp	1.177 g
calorie	4.186 joule	grain, troy	0.065 g
		carat (precious stones)	0.200 g
		ton	
		long (2,240 lb)	1.016 t
		short (2,000 lb)	0.907 t

An additional base unit, the mole (mol), corresponding to the quantity "amount of substance" has been recommended for inclusion in the SI system but has not yet been formally adopted.

The two supplementary units in the SI system are

plane angle	radian (rad)
solid angle	steradian (sr)

Other units in the SI system are derived from these base and supplementary units. Some of the derived units have been assigned special names and symbols. These units are listed in Table 3, together with their formulas and definitions in terms of base units.

Table 3. Derived SI units with special names and symbols.

Quantity	Name of unit	Symbol for unit	Formula and definition of unit in terms of base units
force	newton	N	$kg \cdot m/s^2$
energy	joule	J	$N \cdot m = kg \cdot m^2/s^2$
power	watt	W	$J/s = kg \cdot m^2/s^3$
electric charge	coulomb	C	$A \cdot s$
electric potential	volt	V	$W/A = J/A \cdot s$ $= kg \cdot m^2/A \cdot s^3$
electric capacitance	farad	F	$A \cdot s/V = A^2 \cdot s^4/kg \cdot m^2$
electric inductance	henry	H	$V \cdot s/A = kg \cdot m^2/A^2 \cdot s^2$
electric resistance	ohm	Ω	$V/A = kg \cdot m^2/A^2 \cdot s^3$
magnetic flux	weber	Wb	$V \cdot s = kg \cdot m^2/A \cdot s^2$
magnetic flux density	tesla	T	$Wb/m^2 = kg/A \cdot s^2$
luminous flux	lumen	lm	$cd \cdot sr$
illumination	lux	lx	$lm/m^2 = cd \cdot sr/m^2$
frequency	hertz	Hz	$(cycle)/s = s^{-1} = 1/s$
temperature difference or interval	kelvin	K	
Other recommended units whose names and symbols have not yet been formally adopted			
electric conductance	siemens	S	$\Omega^{-1} = A^2 \cdot s^3/kg \cdot m^2$
pressure	pascal	Pa	$N/m^2 = kg/m \cdot s^2$
Customary units that may be used			
Celsius temperature		°C	0°C = 273.15 K
Celsius temperature difference or interval		°C	1°C = K

Standard prefixes should be used with the SI units to denote quantities larger or smaller than the base and derived units. These prefixes are listed in Table 4. Use of prefixes denoting multiples of 10^3 or 10^{-3} is recommended. Compound prefixes should be avoided:

1 nm (*not* mμm or 1 μmm)

When a prefix is required to provide manageable numbers to express a derived physical quantity, the prefix should usually be attached to the symbol in the numerator:

1MN/m^2 (*not* 1N/mm^2)

When a prefix is attached to a symbol, in effect a new unit is constituted:

$1\ \text{km}^2 = 1\ (\text{km})^2$ *or* $10^6\ \text{m}^2$, *not* $1\ \text{k}(\text{m}^2)$ *or* $10^3\ \text{m}^2$

Table 4. Metric system prefixes, with pronunciation and symbols for multiples and submultiples of the meter, are, liter, and gram.

Multiple or submultiple	Prefix and pronunciation		Symbol
10^{12} = 1,000,000,000,000	tera	ter′a	T
10^9 = 1,000,000,000	giga	ji′ga	G
10^6 = 1,000,000	mega	meg′a	M
10^3 = 1,000	kilo	kil′o	k
10^2 = 100	hecto	hec′to	h*
10 = 10	deka	dek′a	da*
The unit = 1			
10^{-1} = 0.1	deci	des′i	d*
10^{-2} = 0.01	centi	sen′ti	c*
10^{-3} = 0.001	milli	mil′i	m
10^{-6} = 0.000 001	micro	mi′kro	μ
10^{-9} = 0.000 000 001	nano	nan′o	n
10^{-12} = 0.000 000 000 001	pico	pe′co	p
10^{-15} = 0.000 000 000 000 001	femto	fem′to	f
10^{-18} = 0.000 000 000 000 000 001	atto	at′to	a

* This prefix is acceptable in the SI System but is not recommended. SI recommends prefixes denoting multiples of 10^3 and 10^{-3} only.

Additional information on SI is contained in a pamphlet, *ISO Recommendations R1000,* published in the United States by the American National Standards Institute (1970), and in *Standard Metric Practice Guide,* published by the ASTM Committee on Metric Practice (1970).

4. Style in Special Fields

INTRODUCTION

Every biologist faced with the task of producing an acceptable manuscript needs to know not merely how to put words on paper and punctuate sentences; he needs, in addition, to know the conventions in style peculiar to one or more specialized fields, such as anatomy, botany, biochemistry, or zoology. In this chapter are presented the style conventions in several biological fields and in a few others, such as statistics, in which many biologists must have some knowledge. For the convenience of readers, the literature cited for each main section of this chapter is placed at the end of the section. A work cited in this chapter is not included in the Literature Cited at the end of the manual unless it is cited in another chapter.

BOTANY, ZOOLOGY, AND MICROBIOLOGY

Biological nomenclature is designed to achieve stability and universal acceptance of scientific names of organisms. Authors and editors are, by general agreement, obligated to accept the rules governing nomenclature in the *International Code of Botanical Nomenclature* (Lanjouw 1966), the *International Code of Nomenclature of Bacteria* (International Committee on Nomenclature of Bacteria 1966), and the *International Code of Zoological Nomenclature* (Stoll 1961) with its amendments.

Much useful and timely information on botanical nomenclature appears in *Taxon;* similar information on bacterial nomenclature appears in the *International Journal of Systematic Bacteriology,* formerly the *International Bulletin of Bacteriological Nomenclature and Taxonomy.* An annotated list of names of bacteria has been published as *Index Bergeyana* (Buchanan, Holt, and Lessel 1966). The essential features of zoological nomenclature are explained in *Procedure in Taxonomy* (Schenk and McMasters 1956) and in *Principles of Systematic Zoology* (Mayr 1969). Current developments are reported in *Systematic Zoology.* Lists of families, genera, and species are available from the International Trust for Zoological Nomenclature, 14 Belgrave Square, London, S.W.1, England; official decisions on the validity of names are published in *The Bulletin of Zoological Nomenclature.* Because of usage, and because of inherent differences among animals, plants, and microorganisms, the codes differ in certain basic principles and practices.

The need for standards of nomenclature for viruses is reflected in tentative recommendations made at recent meetings of virologists in Montreal, Paris, and Moscow (the Virus Subcommittee of the International Nomenclature Committee 1963; the Provisional Committee for Nomenclature of Viruses (PCNV) 1965; and the International Association of Microbiological Societies 1966).

The International Committee on Nomenclature of Viruses (ICNV) is considering universal systems of nomenclature for all viruses and, despite differences in viewpoint of its members, is attempting to develop a latinized binomial system (Wildy et al. 1967). A subcommittee of the ICNV is tentatively describing virus genera and subgenera, establishing their names, and designating their type species. Included in the subcommittee's study are such RNA viruses as picornaviruses, reoviruses, myxoviruses, and arboviruses, and such DNA viruses as adenoviruses, papovaviruses, and herpesviruses.

BASIC SYSTEMATIC CATEGORIES

The basic nomenclatural groups, categories, or taxa (singular, taxon), in descending order, are phylum or division, class, order, family, genus, and species. The scientific name of a species is a binary combination (bacteriology and botany), a binomen (zoology), or a binomial (botany), and consists of the generic name followed by the specific epithet (botany and bacteriology) or specific name (zoology). The scientific names of all taxa are Latin or latinized forms and are to be so treated.

To be validly published and to have standing in nomenclature, the name of a newly proposed taxon of Recent (not fossil) plants, except bacteria, must be accompanied by a Latin description or a reference to an effectively published description. Initial dates of this requirement are 1 January 1935 for plants other than algae and 1 January 1958 for algae. Authors should not submit (or editors accept) manuscripts that violate this rule. The zoological and bacteriological codes do not require Latin diagnoses.

Names of genera and higher categories may stand by themselves. A generic name followed by a specific epithet or name should be spelled out the first time it is used in the text, but subsequently it may be abbreviated to its capitalized initial letter if the context makes the meaning clear. A specific epithet or name should be preceded by the generic name or its abbreviation except when used in a key, article, or section of an article devoted to a single genus.

INFRASPECIFIC CATEGORIES

The three codes of nomenclature (botany, bacteriology, zoology) differ regarding subdivisions of species. The botanical code recognizes taxa subordinate to species, such as subspecies, varietas, subvarietas, forma, and subforma (*Andropogon ternatus* subsp. *macrothrix; Saxifraga aizoon* var. *aizoon* subvar. *brevifolia* forma *multicaulis* subforma *surculosa*). The botanical term *varietas* (abbreviated var. or v.) is restricted to variant forms of wild plants that have been given Latin names as true botanical varieties, even though they may have been brought into cultivation (*Viola tricolor* var. *hirta*).

The general provisions of the bacteriological code apply to no taxon subordinate to the rank of subspecies, which is considered synonymous with variety. However, the code makes certain recommendations relative to terms used to designate infrasubspecific subdivisions. Terms commonly used are strain, isolate, *forma specialis,* biotype, serotype, morphotype, phagotype, lysotype, phase, and group; others are state, stage, and cultivar.

The zoological code recognizes subspecies and will accept as subspecific names the names proposed for varieties or forms prior to 1961; it will not accept names in infrasubspecific categories proposed after 1960.

HORTICULTURAL VARIETIES

Names of cultivated varieties of plants (cultivars) are printed in roman type set off with single quotes after the Latin names of the species: *Saintpaulia ionantha* 'Calico'; *Lycopersicum esculentum* 'Red Cherry'; many cultivars have Latin names, which must be retained. The *International Code of Nomenclature for Cultivated Plants* (Vilmorin 1961) is the recognized authority for names of horticultural varieties.

CITATION OF AUTHOR

The person first publishing the scientific name for a species or any other taxon is, under regulations prescribed by the biological codes, its author. In taxonomic papers the name of each taxon mentioned should be supplemented with the name of its author: *Homo* Linnaeus; *Musca domestica* Linnaeus; *Magnolia grandiflora* Linnaeus; *Aphis gossypii* Glover 1877; *Clostridium pasteurianum* Winogradsky. In this age of modern systematics, when several types of data are used to characterize taxa, many biologists (both authors and editors) recommend inclusion of the authority with the scientific name of any species mentioned, even in a paper emphasizing physiology, embryology, or other biological aspect of the taxon. The author citation needs to appear only once in an article, preferably in the text with the first mention of the taxon; usually it should not appear in the title. Inclusion of the year in which the name was proposed, as with the species *Aphis gossypii* above, may be important in some articles.

When a species or subspecies is transferred to a genus other than that in which it was first placed, the name(s) of the describer(s) or author(s) is (are) placed in parentheses. In botany and microbiology, the authority for the new combination follows and is not placed in parentheses: *Shigella dysenteriae* (Shiga) Castellani and Chalmers; *Spiraea latifolia* (Ait.) Borkh. The zoological code does not recommend citing the authority of the new combination: *Lepomis gulosus* (Cuvier).

The spelling of its name is sometimes changed when a species is transferred from one genus to another: *Taeniothrips albus* (masculine) became *Frankliniella alba* (feminine) to agree in gender with the new genus.

TYPOGRAPHY

The scientific name of a genus, subgenus, species, subspecies, or other subordinate taxon is normally italicized; the name of a higher taxon is commonly set in roman type. The name of a taxon proposed as new to science (new name, substitute name, or new combination), and appearing in print for the first time, may be set in boldface type. A generic name used as a vernacular or common name is neither italicized nor capitalized: *Petunia,* petunia; *Mastodon,* mastodon; *Bacillus,* bacillus. (Directions for marking words to indicate italic and boldface type are given in Chapter 8.)

The name of a genus or any higher taxon is written with a capital initial letter. The specific or infraspecific epithet or name is not capitalized except where the capital letter is permitted by the botanical code. This code permits using a capital initial letter for a specific or infraspecific epithet derived from the name of a genus, person, or place, but the present tendency among botanists is to avoid this practice.

VERNACULAR OR COMMON NAMES

Many plants and animals are known by their vernacular (provincial, common) names, as well as their scientific names. The vernacular name for an organism may vary from language to language, or from place to place, even within the same country. Nomenclatural rules and customs in various disciplines concern themselves with the use of vernacular names.

The Entomological Society of America maintains definite standards in approving and publishing common names of insects. The last list published (Blickenstaff 1970) contains more than 1,500 names:

> In the case of names having two parts, one of them a group name . . . , the group name will be a separate word when used in a sense that is systematically correct as in "house fly" and "bed bug." If the group name used is not systematically correct, it should be combined in a single word with a modifier as in the examples "citrus whitefly" and "citrus mealybug."

The house fly is a true fly; the citrus whitefly is not. The bed bug is a true bug; the citrus mealybug is not. Because no insect larva is a true worm, the suffix *worm* is always written or printed solid with the modifier: silkworm, not silk worm; striped cutworm, not striped cut worm.

The American Ornithologists' Union (Wetmore 1957) publishes a checklist of North American birds with scientific names for all categories, including species and subspecies. It recognizes vernacular names for species but not for subspecies. The American Fisheries Society maintains a list of common and scientific names of fishes in the United States and Canada. The list is published at irregular intervals as a report of the society's Committee on Names of Fishes (Bailey 1970). Lists have also been published for mammals (Hall 1965), and, by the American Society of Ichthyologists and Herpetologists, for amphibians and reptiles (Conant 1956).

The scientific name of a family (Sciuridae, Chironomidae) may become a vernacular name if the initial letter is lowercased and the terminal *ae* is dropped (sciurid, chironomid).

Most common names of plants are not capitalized, although a name derived from a proper noun may retain the initial capital letter, whether hyphenated or set as two words: Cupid's-dart, Dutchman's-pipe, English ivy, flower-of-Jove, Gray's lily. A proper name that is part of a fanciful common name may have its initial letter lowercased: jack-in-the-pulpit, blue-eyed-mary, brown-eyed-susan. Plant names ending in *bean, berry, bush, cup, flower, grass, lily, nut, pod, root, thorn,* and *wort* are usually printed solid.

In bacteriology, an English common name may be coined from the scientific name of any genus. A generic name is a singular noun and requires a singular verb. Custom sanctions use of the plural for vernacular generic names: The salmonella is . . . ; the salmonellae (brucellae, corynebacteria, clostridia, sarcinae) are . . . . Although the Latin plural is preferred for most vernacular generic names, English plural endings are used exclusively for certain genera (pseudomonads for *Pseudomonas*) and sometimes for others (salmonellas, shigellas, vibrios, sarcinas). Occasionally more than one common name arises from a generic name, as treponema or treponeme from *Treponema,* and streptomycete or streptomyces from *Streptomyces.*

KEYS FOR IDENTIFYING ORGANISMS

The ideal key to a group of organisms presents rigorously selected information in such a way that a series of correct choices leads the user step by step to the identification of one or more organisms. Identification results only if the key has been properly constructed, if the user interprets his material and the key correctly, and if the organisms to be identified have been included in the key. Lawrence (1951), Benson (1962), Metcalf (1954), Blackwelder (1967), and Breed et al. (1957) are good sources of information on the construction and interpretation of keys.

Keys provide primarily, except in the most highly specialized works, useful and practical means of identifying organisms. They are not necessarily accurate pictures of phylogenetic lines or natural relationships. Keys that are designed to show relationships or phylogeny tend to be less functional than others and to become only synopses of taxa.

Several types of keys appear in biological publications. Some keys separate only two species; others separate as many as hundreds of taxa. The most useful keys have a dichotomous construction in the form of couplets permitting only one correct choice. Guiding principles for constructing a key include the following (Metcalf 1954):

1) Simplicity. Write entries in the key as simple, direct, and mutually exclusive couplets, thus constructing a dichotomous key.
2) Clarity. State the first member of a couplet in the positive and the second as a negative or contrasting statement of the character or characters displayed in the first.

3) Reversibility. Construct the key so that it can be used backward as well as forward. Then if you have made an erroneous choice at one couplet you can retrace the steps and find the point of divergence.

The following keys illustrate these principles:

Key to families of the order Myriangiales
(after Wolf and Wolf 1947:163)

A. Asci arising at different levels
B. Stroma massive, of homogeneous texture, without a rind . . . . Myriangiaceae
BB. Stroma effuse, interior gelatinous, exterior crustose . . . . Elsinoeaceae
AA. Asci arising at one level
C. Stroma naked . . . . Saccardiaceae
CC. Stroma with crustose rind
D. Multiloculate . . . . Dothioraceae
DD. Uniloculate or perithecium-like . . . Pseudosphaeriaceae

Key to genera of the family Heteromyidae
(from Cockrum 1962:50)

1. Soles of hind feet densely haired; interparietal less than one-fourth of greatest width of skull 2
1′. Soles of hind feet naked, or haired only from heel to plantar surface; interparietal more than one-fourth of greatest width of skull 3
2(1). Length of hind foot more than 32 mm; tip of tail tufted; occlusal surface of upper premolars elliptical . *Dipodomys*
2′. Length of hind foot less than 32 mm; tip of tail not tufted; occlusal surface of upper premolars rectangular . . . . *Microdipodops*
3(1′). Pelage silky or hispid, never spiny; upper incisors grooved; bullae excessively inflated . . . *Perognathus*
3′. Pelage spiny; upper incisors ungrooved; bullae slightly inflated (not reaching level of grinding surfaces of molars) . . . . *Liomys*

Key to species of the genus *Succinea*
(from Baker 1939:121)

1. Aperture round, not much higher than wide, occupying three-fifths length of shell . . . . *avara,* p. 124

Aperture ovate, occupying three-fourths to four-fifths length of shell, p. 122 2
2. Shell ovoid, somewhat inflated; aperture ovate, spire broad, p. 122 3
Shell much elongated, narrow; aperture narrowly ovate; spire acute, p. 125 4
3. Aperture regularly ovate; color greenish or yellowish . . . . *ovalis*, p. 122
Aperture obliquely ovate, expanded at lower part; color amber . . . . *concordialis*, p. 123
4. Aperture occupying three-fourths length of shell, little expanded at lower part . . . . *retusa*, p. 125
Aperture occupying four-fifths length of shell, notably expanded at lower part . . . . *salleana*, p. 127

LITERATURE CITED IN THIS SECTION

Bailey, R. M., chairman. 1970. A list of common and scientific names of fishes from the United States and Canada. 3rd ed. American Fisheries Society, Washington, D.C.

Baker, F. C. 1939. Fieldbook of Illinois land snails. Ill. Natur. Hist. Surv. Man. 2.

Benson, L. 1962. Plant taxonomy: methods and principles. Ronald Press Company, New York, N.Y.

Blackwelder, R. E. 1967. Taxonomy: a text and reference book. John Wiley & Sons, New York, N.Y.

Blickenstaff, C. C., chairman. 1970. Common names of insects approved by the Entomological Society of America. Entomological Society of America, College Park, Md.

Breed, R. S., E. G. D. Murray, N. R. Smith, and 94 contributors. 1957. Bergey's manual of determinative bacteriology. 7th ed. Williams & Wilkins Company, Baltimore, Md.

Buchanan, R. E., J. G. Holt, and E. F. Lessel, Jr. 1966. Index Bergeyana. An annotated alphabetic listing of names of the taxa of the bacteria. Williams & Wilkins Company, Baltimore, Md.

Cockrum, E. L. 1962. Laboratory and field manual for introduction to mammalogy. 2nd ed. Ronald Press Company, New York, N.Y.

Conant, R., chairman. 1956. Common names for North American amphibians and reptiles. Copeia 1956:172–185.

Hall, E. R. 1965. Names of species of North American mammals north of Mexico. Univ. Kans. Mus. Natur. Hist. Misc. Publ. 43.

International Association of Microbiological Societies. 1966. IX International Congress for Microbiology, Moscow, 1966. Symposia. Pergamon Press, Elmsford, N.Y.

International Committee on Nomenclature of Bacteria. 1966. International code of nomenclature of bacteria. Int. J. Syst. Bacteriol. 16:459–490.

Lanjouw, J., chairman. 1966. International code of botanical nomenclature. International Bureau for Plant Taxonomy and Nomenclature. Utrecht, Netherlands.

Lawrence, G. H. M. 1951. Taxonomy of vascular plants. The Macmillan Company, New York, N.Y.

Mayr, E. 1969. Principles of systematic zoology. McGraw-Hill Book Company, New York, N.Y.

Metcalf, Z. P. 1954. The construction of keys. Syst. Zool. 3:38–45.

Provisional Committee for Nomenclature of Viruses (PCNV). 1965. Proposals and recommendations of the Provisional Committee for Nomenclature of Viruses (PCNV). Ann. Inst. Pasteur (Paris) 109(5):625–637.

Schenk, E. T., and J. H. McMasters. 1956. Procedure in taxonomy. 3rd ed. Stanford University Press, Stanford, Calif.

Stoll, N. R., chairman. 1961. International code of zoological nomenclature adopted by the XV International Congress of Zoology. International Commission on Zoological Nomenclature.

Vilmorin, R. de, chairman. 1961. International code of nomenclature for cultivated plants. Regnum Veg., vol. 22.

Virus Subcommittee of the International Nomenclature Committee. 1963. Minutes of meetings of the Subcommittee on Taxonomy of the Viruses, Montreal, 1962. Int. Bull. Bacteriol. Nomencl. Taxon. 13:217–222.

Wetmore, A., chairman. 1957. Check-list of North American birds. 5th ed. American Ornithologists' Union, New York, N.Y.

Wildy, P., H. S. Ginsberg, J. Brandes, and J. Maurin. 1967. Virus-classification, nomenclature and the International Committee on Nomenclature of Viruses. Prog. Med. Virol. 9:476–482.

Wolf, F. A., and F. T. Wolf. 1947. The fungi. 2 vols. John Wiley & Sons, New York, N.Y.

ANATOMY

The International Anatomical Nomenclature Committee (1968) has published an official revised list of human gross anatomical terms in Latin. Also, the International Committee on Veterinary Anatomical Nomenclature (1968) has published a list of anatomical terms in Latin for cat, dog, swine, cattle, sheep, goat, and horse. Subcommittees are at work on standardization of terms in embryology and histology.

For species other than man and domestic mammals, terms based on the same principles are being prepared. Until an official list is available, these rules should be followed: (i) well-established terms should not be altered merely on pedantic or etymological grounds; (ii) each structure should be designated by one term only; and (iii) differentiating terms should be arranged as opposites, for example, *major* and *minor*.

Anatomical terms derived from Latin are regarded as common nouns and consequently should not be capitalized; neither should they be italicized. In biological writing, the vernacular equivalent may be substituted for the Latin form of any term. The form of some terms (femur, cisterna chyli) is not changed; the form of others (tela subcutanea or subcutaneous tissue) may or may not be changed. Most terms are given in anglicized form, or English equivalents may be substituted (brachial plexus instead of plexus brachialis, and stomach instead of ventriculus). Antiquated names and obsolete usage should be avoided.

LITERATURE CITED IN THIS SECTION

International Anatomical Nomenclature Committee. 1968. *Nomina anatomica.* 3rd ed. Excerpta Medica Foundation, New York, N.Y.

International Committee on Veterinary Anatomical Nomenclature. 1968. *Nomina anatomica veterinaria.* World Association of Veterinary Anatomists, Vienna.

GENETICS AND CYTOGENETICS

In genetics and cytogenetics, as in other fields of biology, many rules of nomenclature have developed informally and have become established through wide use rather than by formal agreements among authorities. The number of symbols currently employed to designate genes and chromosomes is too large to permit complete description in this manual. General rules for genetic nomenclature and symbols were summarized by Y. Tanaka for the X International Congress of Genetics and distributed privately; they have been supported and modified by resolutions of the XI and XII International Congresses of Genetics.

Compilations of gene symbols for many plants and animals, with additional pertinent information including linkages, can be found in *Handbook of Biochemistry* (Sober 1970) and *Biology Data Book* (Altman and Dittmer 1964); coverage includes maize, tomato, *Saccharomyces, Neurospora crassa, Aspergillus nidulans, Coprinus radiatus, Streptomyces coelicolor, Escherichia coli* bacteriophage lambda, bacteriophage T4, *Chlamydomonas reinhardi, Bacillus subtilis, Escherichia coli, Salmonella typhimurium,* silkworm (*Bombyx mori*), parasitic wasp (*Habrobracon juglandis,* now *Bracon hebetor*), fruit fly (*Drosophila melanogaster*), chicken, rabbit, rat, mouse, guinea pig, cat, and man.

BACTERIA

A system of uniform nomenclature in bacterial genetics described by Demerec et al. (1966) provides for designation of genotypes (including loci, mutation sites, plasmids and episomes, sex factors), phenotypes, and bacterial strains. It also provides for standardized symbols.

Genotype Symbols. In the representation of a genotype, each locus of a given wild-type strain of bacteria is designated by a symbol consisting of three lowercase italic letters. For example, *ara* refers to the loci in which occur mutations that affect the response of the cell to arabinose as a source of carbon and energy. Different loci, any one of which may mutate to produce the same gross phenotypic change, are distinguished from one another by an italic capital letter added immediately after the three lowercase letters: symbols *araA*, *araB*, and *araC* refer to loci that control arabinose utilization. Specific recommendations cover loci involved in genetic regulation, loci that govern resistance and sensitivity, and suppressor loci.

A mutation site should be designated by a serial isolation number placed after the locus symbol. If it is not known in which of several loci that govern related functions the mutation has occurred, a hyphen is substituted for the capital letter. For example, the mutation sites that were provisionally designated *ara-1*, *ara-2*, and *ara-3* were designated *araB1*, *araA2*, and *araC3* after the altered enzymes had been identified.

The wild-type allele of a locus is designated by a plus sign; thus, *araB*+ is the wild-type allele of the *araB* locus.

Plasmids and episomes should be designated by symbols clearly distinguishable from those used for gene loci. The first letter of a symbol for a plasmid or an episome is capitalized; the symbol is not italicized, and it is placed in parentheses: (Col E1). Mutant loci and mutation sites on plasmids and episomes should be designated by symbols of the same kind as those used for loci and sites on the chromosome. The description of a strain carrying an episome should include a statement about the state or the location of the episome, or both.

A genotype symbol that has been published and that conforms to the recommended system should not be changed. One that does not conform to the system should be changed to accord with it, and the change should be noted when the new symbol is first published.

Phenotype Abbreviations. Phenotypic traits should be described in words or designated by abbreviations that are defined the first time they appear in a paper (Demerec et al. 1966). The phenotype abbreviations should be clearly distinguishable from genotype symbols. Whereas a genotype symbol consists of three italic lowercase letters, a phenotype abbreviation consists of three roman letters, the first of which is capitalized. The same letters may be used for a genotype symbol and a phenotype abbreviation. For example, the phenotype Met− is associated with a mutation in the *metA* locus.

Strain Designations. Strains should be designated by simple serial numbers (Demerec et al. 1966). To prevent duplication, each laboratory should use a letter prefix different from that of any other laboratory. Strain designations should not be italicized. A designation that has been published and that conforms to the accepted recommendations should not be changed. A designation that does not conform should be changed to accord with the recommendations, and the change should be noted when the new designation is first published.

YEAST

Rules for a system of symbols for the genes of yeast and a catalog of proposed symbols have been published by von Borstel et al. (1969). The system is similar to that described for bacteria.

MAIZE

Chromosome constitution of maize should be described according to the conventions of Rhoades (1957). All chromosome symbols are in italics and are on the same line.

In gene symbols, subscript characters are used to represent loci that give phenotypically similar effects (V_1, V_2). Superscript characters are used for different members of an allelic series (R^s).

WHEAT

A system adopted by the International Wheat Genetics Group for the description of aneuploids provides the symbolism for complete and aberrational chromosomes (telocentric chromosomes, isochromosomes, pairing status, chromosome substitutions, complex multivalents) and for designation of chromosomes and chromosome arms (Kimber and Sears 1968).

OATS

The rules for symbolization of genes in oats (all diploid, tetraploid, and hexaploid species of *Avena*) are described, with a catalog of gene symbols and references, by Simons et al. (1966).

FLAX

Symbols for genes of flax (*Linum usitatissimum*) and rules for establishing symbols have been published by Beard and Comstock (1965). The conventions are based on rules established by the Tenth International Congress of Genetics and modifications by the Rice Gene Symbolization Committee.

TOMATO

Rules for chromosome description and for designation of mutant genes have been drawn up by the Tomato Genetics Cooperative (Clayberg et al. 1970); lists of known genes have been compiled by Barton et al. (1955) and by Clayberg et al. (1960, 1966). Many of the chromosome symbols are the same as those for maize, but italic letters are reserved for gene symbols; chromosome symbols are roman characters. A new name or symbol should be cleared with either the Gene List Committee or the Coordinating Committee of the Tomato Genetics Cooperative before it is used in a publication.

FRUIT FLY

For descriptions of genetic variants of the fruit fly *Drosophila melanogaster,* widely accepted conventions stipulate usage for symbolic representation of mutants and chromosome aberrations. A detailed account of these conventions, which should guide authors in the formation of new symbolic descriptions, is given by Lindsley and Grell (1968). Symbols for both mutants and chromosome aberrations are italicized; they never contain Greek letters, subscripts, or spaces. The spelled-out names of mutants are not italicized.

Symbols for mutant types are abbreviations of their characterizing names. Usually a symbol begins with the first letter of its name; the convention of an initial capital letter for a dominant and an initial lowercase letter for a recessive is employed:

r rudimentary (a recessive mutant)
R Roughened (a dominant mutant)
ry rosy (a recessive mutant)

Designations of genotypes with several mutant genes follow the rules outlined below:

Genes on same chromosome	Separate the gene symbols with spaces (*y w f B*)
Genes on homologous chromosomes	Separate symbols with slash mark (*y w f/B*)
Genes on nonhomologous chromosomes	Separate symbols with semicolons and spaces (*bw; e; ey*)

Alleles at a particular locus are represented by the same symbol (and name) but are differentiated from one another by italicized superscripts: arbitrary numbers, experiment numbers, capitalized initials (representing finder or laboratory), or discovery date. Lindsley and Grell (1968:4–5) should be consulted for conventions governing superscripts of a recessive allele of a preponderantly dominant series, a dominant allele of a preponderantly recessive series, the normal allele, absence of a locus, or loci controlling electrophoretic mobility of proteins (including enzymes), and for conventions for designation of mimics, modifiers, and suppressor genes.

A wild-type allele is symbolized by a superscript plus sign after the locus designation (a^+), or by only a plus sign on the line (+) if the locus is identified by the context. A capital letter is never used to designate the wild-type allele of a recessive mutation, as is often done in plant and mammalian genetics.

Chromosome aberrations are designated according to the elementary rearrangements: deficiency, duplication, inversion, ring, translocation, and transposition (abbreviated, respectively, *Df, Dp, In, R, T,* and *Tp*). Further details on symbols for the six types of rearrangement may be found in Lindsley and Grell (1968:286–289).

MOUSE

Rules for the symbolic designation of genes of the laboratory mouse have been published in a report of the Committee on Standardized Genetic Nomenclature for Mice (1963). With some exceptions, the rules are similar to those for *Drosophila melanogaster*. The symbol for a gene is typically the abbreviation for the gene name (*d* for dilution, *ac* for absence of corpus callosum); the abbreviation, which is italicized, should begin with the same letter as the name. The name of a gene is written with a lowercase initial letter, whether the mutant is recessive or dominant, except where capitalization is normally used (as at the beginning of a sentence) or the name contains a proper noun (Jay's dominant spotting). The symbol for a recessive mutant gene has a lowercase initial letter (*a* for non-agouti) and that for a dominant mutant has a capital initial letter (*Re* for rex). The symbol for a gene locus is the symbol of the first-named mutant gene, or allelic pair of genes, without superscript for a specific allele.

The wild-type may be designated by (i) the locus symbol with a lowercase initial letter and a superscript plus (re^{+}); (ii) a plus sign alone if the context leaves no doubt as to the locus represented; or (iii) the same symbol as for the mutant gene but with a capital initial letter for a recessive mutant and a lowercase initial letter for a dominant mutant (*D* for the wild-type allele of *d; re* for the wild-type allele of *Re*). For most purposes, the first two methods of designation are preferred to the third.

Multiple alleles determining visible or other clear distinctions are represented by the locus symbol with a superscript, usually a lowercase letter, or letters, indicative of the name; the initial letter of the symbol is capitalized if the allele behaves as a dominant. The symbols for gene loci and alleles should be italicized.

Further details on these conventions and on those for mimics, variants of a series, indistinguishable alleles of independent origin, reversions to wild-type, and translocations are included in the report of the Committee on Standardized Genetic Nomenclature for Mice (1963). Special rules for nomenclature of inbred strains, with an index list of these strains and their clearly differentiated substrains, have been summarized for the Committee (Staats 1968).

CAT

The only established conventions now available for describing chromosomes of nonhuman vertebrates are those for grouping and numbering the chromosomes of the family Felidae. Grouped chromosomes are designated alphabetically, beginning with A; sex chromosomes are represented by X and Y. Chromosomes within each group are designated by arabic numerals. The chromosome groups and numbers for *Felis catus* are as follows:

Group A	A1, A2, A3	Large submetacentric chromosomes
Group B	B1, B2, B3, B4	Large subtelocentric chromosomes
Group C	C1, C2	Large metacentric chromosomes
Group D	D1, D2, D3, D4	Small submetacentric and subtelocentric chromosomes (if any)

Group E	E1 (satellited), E2, E3	Small metacentric chromosomes, the first pair satellited
Group F	F1, F2	Telocentric or acrocentric chromosomes; the pairs are identical
Sex pair	XY	

Smith and Jones (1966) give additional information on this subject. A source of current information is a mimeographed publication that confines its circulation to active investigators: *Chromosomes Newsletter,* edited by T. C. Hsu and "arranged" by the Section of Cell Biology, the University of Texas M. D. Anderson Hospital and Tumor Institute, Houston, Texas 77025.

MAN

Detailed rules for description of the human chromosome complement and its abnormalities, both numerical and structural, were established at the 1966 Chicago Conference on Standardization in Human Cytogenetics (The National Foundation 1966). The system of description employs symbols (Table 1), to be used in a prescribed sequence: the total number of chromosomes, including the sex chromosomes; the sex chromosome constitution; and symbols for structural abnormalities. For example, the sequence 46,XX,D−,t(DqGq)+ indicates 46 chromosomes; two X chromosomes; one chromosome missing from the D group, the long arm of this chromosome translocated to the long arm of a G group chromosome. The report of the conference should be consulted by authors for the specific rules governing the proper use of the symbols in Table 1 to describe all numerical aberrations and structural alterations.

At the conference, requirements for complete and accurate descriptions of populations, families, and individuals were specified. Typographic conventions that should be followed with special care include those for identifying persons studied and those for numbering generations and individuals in tables and pedigrees. Each person is to be clearly identified by initials, birth date, and any other necessary symbols; for example, John Smith born on 21 July 1954 is identified as JS210754. In tables and pedigrees, generations are to be numbered with roman

Table 1. Symbols and abbreviations used in human cytogenetics.

Symbol or abbreviation	Explanation
A–G	letters designating the chromosome groups
1–22	numerals designating the autosome numbers (Denver system)
X, Y	letters designating the sex chromosomes
/ (diagonal or slant)	mark separating cell lines in description of mosaicism
+ (plus sign) or − (minus sign)	sign placed immediately after autosome number or group letter designation to indicate extra (+) or missing (−) chromosome
	sign placed immediately after arm or structural designation to indicate larger (+) or smaller (−) than normal arm or structure
? (question mark)	mark indicating questionable identification of chromosome or chromosome structure
* (asterisk)	mark designating a chromosome structure explained in text or footnote
ace	acentric
cen	centromere
dic	dicentric
end	endoreduplication
h	secondary constriction or negatively staining region
i	isochromosome
inv	inversion
inv (p+ q−) or inv (p− q+)	pericentric inversion
mar	marker chromosome
mat	maternal origin
p	short arm of chromosome
pat	paternal origin
q	long arm of chromosome
r	ring chromosome
s	satellite
t	translocation
tri	tricentric
Repeated symbols	duplication of chromosome structure

numerals, beginning with I for the most senior generation. Members of each generation are to be numbered with arabic numerals, beginning with 1 for the most senior member (at the left in a pedigree).

LITERATURE CITED IN THIS SECTION

Altman, P. L., and D. S. Dittmer, editors. 1964. Biology data book. Federation of American Societies for Experimental Biology, Washington, D.C.

Barton, D. W., L. Butler, J. A. Jenkins, C. M. Rick, and P. A. Young. 1955. Rules for nomenclature in tomato genetics. J. Hered. 46:22–26.

Beard, B. H., and V. E. Comstock. 1965. Flax genetics and gene symbolism. Crop Sci. 5:151–155.

Clayberg, C. D., L. Butler, E. A. Kerr, C. M. Rick, and R. W. Robinson. 1966. Third list of known genes in the tomato, with revised linkage map and additional rules. J. Hered. 57:189–196.

———. 1970. Rules for nomenclature in tomato genetics. Report of the Tomato Genetics Cooperative 20:3–5.

Clayberg, C. D., L. Butler, C. M. Rick, and P. A. Young. 1960. Second list of known genes in the tomato including supplementary rules for nomenclature. J. Hered. 51:167–174.

Committee on Standardized Genetic Nomenclature for Mice. 1963. A revision of the standardized genetic nomenclature for mice. J. Hered. 54:159–162.

Demerec, M., E. A. Adelberg, A. J. Clark, and P. E. Hartman. 1966. A proposal for a uniform nomenclature in bacterial genetics. Genetics 54:61–76.

Kimber, G., and E. R. Sears. 1968. Nomenclature for the description of aneuploid in the Triticinae. Proc. 3rd Int. Wheat Genet. Symp. Canberra, 1968. Aust. Acad. Sci., Canberra, pp. 468–473.

Lindsley, D. L., and E. H. Grell. 1968. Genetic variations of *Drosophila melanogaster*. Carnegie Inst. Wash. Publ. 627.

Rhoades, M. M. 1957. Genetic nomenclature in maize. Pages 1–3 *in* Maize Genetics Cooperation News Letter 31.

Simons, M. D., F. J. Zillinsky, and N. F. Jensen. 1966. A standardized system of nomenclature for genes governing characters of oats. Crops Research ARS 34–85. Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C.

Smith, H. A., and T. C. Jones. 1966. Genetically determined disease; cytogenetics. Pages 298–320 *in* Veterinary pathology. 3rd ed. Lea & Febiger, Philadelphia, Pa.

Sober, H. A., editor. 1970. Handbook of biochemistry. Selected data for molecular biology. 2nd ed. Chemical Rubber Co., Cleveland, Ohio.

Staats, J. 1968. Standardized nomenclature for inbred strains of mice: fourth listing. Cancer Res. 28:391–420.

The National Foundation. 1966. Chicago Conference: Standardization in human cytogenetics. Birth defects: Original article series, II:2. (Reprints are available from The National Foundation–March of Dimes, 800 Second Avenue, New York, N.Y. 10017.)

von Borstel, R. C., R. K. Mortimer, F. Sherman, G. E. Magni, and S. Nakai. 1969. Yeast genetics supplement to Microbial Genetics Bulletin 31. Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

IMMUNOLOGY

The development of immunology has been so rapid in the past two decades that in only a few areas of the field have formal conventions for terminology and symbols been established. The formal proposals that have been drawn up for several aspects of human immunology may be useful guides for immunology of infrahuman species.

HUMAN IMMUNOGLOBULINS

Recommendations for nomenclature and symbols for the immunoglobulins and their genetic factors have been described in memorandums drafted by expert committees for the World Health Organization (1964, 1965, 1966, 1968*a,* 1969) and in a short summary by Rowe (1970). The memorandums of 1964, 1965, 1966, and 1969 have been reprinted on pages A-90 through A-99 of the *Handbook of Biochemistry* (Sober 1970).

Abbreviated notations for major classes of immunoglobulins are made up of the symbol Ig or γ followed by a capital letter designating the specific class:

γG or IgG
γA or IgA
γM or IgM
γD or IgD
γE or IgE

The two major groups of polypeptide chains are known at present by the terms *light* and *heavy*. The heavy chains are designated by lowercase Greek letters corresponding to the Roman capital letters used for the immunoglobulin classes:

IgG	γ (gamma) as in "γ-chain"
IgA	α (alpha)
IgM	μ (mu)

The immunoglobulins identified by the properties of light chains are designated type K and type L; the notations for their corresponding light chains are κ (kappa) and λ (lambda).

Recommendations for symbols to represent the variable and constant regions of the polypeptide chains and for formulas for immunoglobulin molecules are given in a memorandum of the World Health Organization (1969).

The general system for notation of immunoglobulin subclasses was described in the World Health Organization memorandum of 1966. A subclass is indicated by an arabic numeral following the class letter, for example IgG1, IgG2, and IgG3. A potential new subclass should be designated temporarily by a patient's initials, by a letter or letters representing a city, or by a similar symbol in parentheses: for example, IgG (Pr) for a potential new subclass identified in Prague (World Health Organization 1964). The final numerical notation should be assigned only after several laboratories have exchanged reagents and agreed on the categorization.

Development of a notational system for the genetic factors of human immunoglobulins has been hampered by insufficient information for precise correlation of genetic loci with the structures they influence. The symbols Gm and Inv are followed by arabic numerals within parentheses for the various factors, for example, Gm(1), Gm(2), Inv(1), and Inv(2). The phenotypes for an individual can be indicated in either of two ways: by recording the positive or negative result with each set of reagents, for example, Gm (1, −2, 3, 4, 5); or by recording only the positive results, for example, Gm (1, 3, 4, 5), in which case the reagents used must be specified separately. Symbols for genes are set in italic type (underlined in typescript), and the factors determined by the gene are indicated by superscript digits: for example, for phenotype Gm(1,5) the most probable genotype is presented as Gm^1/Gm^5.

The 1964 WHO memorandum cited above and the pages on human immunoglobulins in the *Handbook of Biochemistry* (Sober 1970) should be consulted for recommendations for designation of immunoglobulin fragments and immunoglobulins in proliferative disorders of lymphocytic or plasmacytic cells.

HUMAN COMPLEMENT

A provisional recommendation for a new system of symbols for components of human complement and related complexes has been issued as a memorandum under auspices of the World Health Organization (1968*c*). The earlier system based on the symbol C′ and subsidiary symbols is to be replaced by the symbols, in order of their reaction, C1 (with subcomponents C1q, C1r, and C1s), C4, C2, C3, C5, C6, C7, C8, and C9. (The anomalous place of C4 is a concession to prior usage.) Symbols for intermediate complexes are developed from E (erythrocyte), S (site of initiation of complement fixation), and A (antibody) in conjunction with C, followed by the numerals for the components that have interacted. EAC1423, for example, represents the intermediate complex produced by reaction of the first four components. The letters and numerals should not be subscript.

The WHO memorandum mentioned above includes descriptions of complement components showing altered activity, descriptions of fragments and chains, a table of previous designations in association with the proposed symbols, and a table of other factors reacting in the complement sequence.

HUMAN HISTOCOMPATIBILITY LEUKOCYTE ANTIGENS

The major gene locus for the system of leukocyte antigens related to human histocompatibility has been designated HL-A. Specific serological factors are indicated by numbers following HL-A: for example, HL-A1, HL-A2. Additional factors having a high positive correlation with a primary factor are indicated by a second number following a decimal point: for example, HL-A2.1 for a factor associated with the original factor HL-A2.

A local designation may be used for a new factor before certification of a factor number is obtained from the WHO Nomenclature Committee for leukocyte antigens.

Other details of this system of nomenclature, including recommendations for representation of phenotype and genotype, along with a table showing the relationships of factors HL-A1, 2, 3, 5, 7, and 8 to previous designations, are given in a report of the Nomenclature Committee of the World Health Organization (1968*b*).

LITERATURE CITED IN THIS SECTION

Rowe, D. S. 1970. Nomenclature of immunoglobulins. Nature (London) 228:509–511.

Sober, H. A., editor. 1970. Handbook of biochemistry. Selected data for molecular biology. 2nd ed. The Chemical Rubber Co., Cleveland, Ohio.

World Health Organization. 1964. Nomenclature for human immunoglobulins. Bull. World Health Organ. 30:447–450.

———. 1965. Notation for genetic factors of human immunoglobulins. Bull. World Health Organ. 33:721–724.

———. 1966. Notation for human immunoglobulin subclasses. Bull. World Health Organ. 35:953.

———. 1968*a*. Immunoglobulin E, a new class of human immunoglobulin. Bull. World Health Organ. 38:151–152.

———. 1968*b*. Nomenclature for factors of the HL-A system. Bull. World Health Organ. 39:483–486.

———. 1968*c*. Nomenclature of complement. Bull. World Health Organ. 39:935–938.

———. 1969. An extension of the nomenclature for immunoglobulins. Bull. World Health Organ. 41:975–978.

HEMATOLOGY

Informal and formal conventions for symbols in hematology were developed first and most extensively for human blood and serum groups, clotting factors, and red cell enzymes. Some of these conventions have been used for infrahuman as well as the human species.

BLOOD AND SERUM GROUPS

Blood group antigens and serum factors in man and other animals are conventionally represented by capital and lowercase roman letters. These letters have been arbitrarily assigned (as for the A-B-O blood groups in man), but some stand for the name of the human subject (for example, Le for Lewis, Fy for Duffy) or animal that served as the identifying source. Genes corresponding to the antigens are usually represented by the same letters in italics. The antibody corresponding to a particular antigen is represented by the symbol for the antigen prefaced by *anti*.

Human Blood Groups. Symbols currently in use for human blood groups follow the pattern described in the preceding paragraph and can be found in standard references (Prokop and Uhlenbruck 1969; Race and Sanger 1968; Erskine 1970*a*).

The Rh system (Rh for antigen from the rhesus monkey) has been represented with a scheme of notation based on capital and lowercase letters C, D, E (Race and Sanger 1968). However, the Rh-Hr notation of Wiener (1967; also see Prokop and Uhlenbruck 1969 and Erskine 1970*b*) more efficiently represents the serological and genetic basis for the Rh system and is generally preferred in the United States.

Infrahuman Blood Groups. There is no convention preventing the use of the same or similar alphabetical symbols in different species (Cohen 1962; Erskine 1970*a*); therefore, unless the context of a discussion of animal blood groups makes ambiguity unlikely, the species to which a particular symbol refers should be mentioned. Special attention should be given to achieving a clear identification of a particular blood group system as an isoantigen-antibody system in a single species, or a system also existing or producible in a second, unstated species. Problems in symbolic representation of human-infrahuman interacting systems are discussed by Prokop and Uhlenbruck (1969:417–429).

Human Serum Groups. Symbols for serum-factor systems (such as the haptoglobin, Gm, Inv, Gc, and Ag systems) have developed informally on a basis similar to that described for the blood groups (Prokop and Uhlenbruck 1969). An international committee of the World Health Organization (1965) has published a recommendation for a standardized system for the Gm and Inv systems (see page 80).

Human Clotting Factors. By international agreement among a number of authorities on blood coagulation, the various adequately characterized human clotting factors known by descriptive or eponymic terms are now designated by roman numerals, for example, Factor IX for plasma thromboplastin component (PTC) or Christmas factor. This agreement, characterization of the factors, and a tabulation of the roman-numbered factors with their synonyms have been published by the International Committee on (for the) Nomenclature of Blood Clotting Factors (1959, 1960, 1962). Either the numbers or the eponymic names may be used, as an author prefers, but the agreement recommends that both forms be used the first time a factor is mentioned in a paper.

HEMOGLOBINS

The hemoglobins of humans have been investigated far more extensively than those of lower animals. Consequently, descriptive conventions for human hemoglobins have been developed in much more detail than for hemoglobins of other vertebrates.

Human Hemoglobins. The molecules of the three normal human hemoglobin fractions (hemoglobin A, hemoglobin A_2, hemoglobin F) are composed of four heme groups and globin, which itself is composed of two pairs of polypeptide chains. These chains are designated by the Greek letters alpha (α), beta (β), gamma (γ), and delta (δ). The globin of the normal main human hemoglobin fraction, hemoglobin A (Hb A), is made up of two alpha and two beta chains ($\alpha_2\beta_2$); hemoglobin F, of two alpha and two gamma chains ($\alpha_2\gamma_2$); and the minor fraction, hemoglobin A_2, of two alpha and two delta chains ($\alpha_2\delta_2$).

The genes determining the structure of hemoglobin should be represented by the italicized gene symbol *Hb* followed by the subscript for the chain that it specifies, for example, Hb_α, Hb_β, Hb_γ, Hb_δ, and Hb_ϵ.

The abnormal hemoglobins that were first characterized by their electrophoretic mobility at pH 8.6 have been designated by letters of the alphabet: C through Q, and S.

The recently described hemoglobins have been given names of localities, laboratories, or hospitals representing the origin of the propositus or the place where the hemoglobin was identified, for example, Hb Chad and Hb Bart's. This convention should be used for newly discovered hemoglobins; previously used geographical labels, for example, Hb Hopkins-1 and Hb Hopkins-2 should not be repeated. The use of personal names should be avoided.

Comparison of an apparently newly identified hemoglobin with previously known hemoglobins by methods such as zone electrophoresis, solubility, and column chromatography may or may not establish its identity as a "new" hemoglobin. If the hemoglobin appears to be identified with one previously described, it should not, of course, be given a new name; proof that it is a mutant hemoglobin not previously described, and that it should be given a new name, will require determination of the amino acid substitution or other primary structural alterations.

Some letters identify hemoglobins in a group of hemoglobins of identical properties, primarily electrophoretic mobility. If the abnormal polypeptide chain of such a hemoglobin is known, it should be indicated: for example, Hb Gα. Such a hemoglobin may be further identified with a geographical label: for example, Hb Gα Philadelphia, Hb Gα Norfolk.

Abnormal hemoglobins are more precisely described by indicating the specific locations of the amino acid differences in the polypeptide chains. Hb M Iwate, for example, differs from the normal Hb A by substitution for the heme-linked histidine by tyrosine at the 87th position in the α chain. This mutation is indicated as 87 His → Tyr.

Most of the globins consist of an initial segment (NA), the helical amino acid segments (A-H), the interhelical segments (AB, BC, and so forth), and a terminal sequence (HC). These symbols for the N- and C-terminals do not correspond to those recommended by IUPAC for NH_2- and COOH-terminals (see page 107).

A mutation can be identified by its position in one of these segments, rather than in the entire amino acid sequence of the whole chain; thus, the mutation characteristic of Hb M Iwate can be described as F8 His → Tyr, indicating the substitution of tyrosine for the histidine, which is the eighth amino acid in the F helical segment of the alpha chain. Alternative forms of complete description of this hemoglobin are Hb M Iwate, $\alpha87$ His → Tyr; or Hb M Iwate, αF8 His → Tyr. Superscript forms with or without the replaced amino acid are used in some journals ($\alpha_2^{87\ \mathrm{His}\rightarrow\mathrm{Tyr}}\beta_2$ or $\alpha_2^{87\ \mathrm{Tyr}}\beta_2$), but they are not used in other journals because of the cost of setting special characters as subscripts or superscripts.

The sources of the globin chains from which experimental hybrid hemoglobins are formed should be described. For example, a hemoglobin formed of alpha chains from Hb I and beta chains from Hb C should be designated as $\mathrm{Hb}_{\alpha_2^{\mathrm{I}}\beta_2^{\mathrm{C}}}$.

Other details of current conventions for the descriptions of human hemoglobins and especially of those abnormalities involving minor components are described in a statement from the Tenth International Congress of Haematology (Anon. 1964) and in a paper by Perutz and Lehmann (1968).

Infrahuman Hemoglobins. The main hemoglobin characteristic of an infrahuman species has customarily been designated Hb A with a preceding or following modifier to indicate genus of the infrahuman species, for example, canine Hb A or Hb $\mathrm{A}^{\mathrm{can}}$. Hemoglobins described subsequently have been designated by B, C, and so forth. This system is not adequate for more detailed or comparative descriptions. The system used for human hemoglobins can be employed in the description of newly discovered hemoglobins of infrahuman animals, pending agreement on a widely accepted convention among veterinarians and comparative hematologists, but the abbreviations and symbols must be explained by the author.

HUMAN GLUCOSE-6-PHOSPHATE DEHYDROGENASE

The phenotypic symbol for glucose-6-phosphate dehydrogenase (EC 1.1.1.49) is Gd; the symbol for the corresponding gene is *Gd*.

The symbol Gd should be followed by indications of enzyme activity relative to the normal B enzyme. Normal activity is (+); various degrees of lesser and greater activity are indicated by (−), (±), (++), and similar graduated steps. The activity indicator should be followed by a comma and the specific symbol or name of the variant. The symbols B, A, and A− are retained for these widely recognized variants; other known variants have geographical or trivial names. Names for new variants should not contain broad geographical terms (such as continental or national names), or ethnic names, family names, further alphabetical designations, or numerals suffixed to geographical names.

A name should not be definitely assigned to a supposedly new variant until it has been fully characterized by appropriate studies to distinguish it from known variants. Before such characterization, the name should be enclosed in quotation marks, which should be dropped after the variant has been confirmed as new.

The genotypic symbol *Gd* is modified to indicate a specific allele with a superscript symbol or name set in smaller roman type. The two terms in the genotypic designation for a female heterozygote should be separated by a slant line. The acceptable informal abbreviation for the enzyme is G6PD.

Additional details on nomenclature and symbolization, and recommendations for drafting the names of new variants, may be found in a report of a WHO scientific group (World Health Organization 1967).

LITERATURE CITED IN THIS SECTION

Anonymous. 1964. Nomenclature of haemoglobins. [Recommendations unanimously accepted at the Tenth International Congress of Haematology, Stockholm, 1964.] Brit. Med. J. 2:1258.

Cohen, C., editor. 1962. Blood groups in infrahuman species. Ann. N. Y. Acad. Sci. 97:1–328.

Erskine, A. G. 1970*a*. Other blood group systems and blood groups of nonhuman primates. Pages 820–846 *in* Gradwohl's clinical laboratory methods and diagnosis. 7th ed. Edited by S. Frankel, S. Reitman, and A. C. Sonnenwirth. C. V. Mosby Company, St. Louis, Mo.

Erskine, A. G. 1970*b*. The Rh-Hr system. Pages 752–785 *in* Gradwohl's clinical laboratory methods and diagnosis. 7th ed. Edited by S. Frankel, S. Reitman, and A. C. Sonnenwirth. C. V. Mosby Company, St. Louis, Mo.

International Committee for the Nomenclature of Blood Clotting Factors. 1962. The nomenclature of blood clotting factors. J. Amer. Med. Ass. 180:733–735.

International Committee on Nomenclature of Blood Clotting Factors. 1959. Nomenclature of blood clotting factors: four factors, their characterization and international number. J. Amer. Med. Ass. 170:325–328.

———. 1960. New blood clotting factors: Transactions of the conference held under the auspices of the International Committee on Blood Clotting Factors, Montreux, Switzerland, August 24–26, 1959. Pages 262–278 *in* Supplementum ad Volume IV, Thrombosis et Diathesis Haemorrhagica.

Perutz, M. F., and H. Lehmann. 1968. Molecular pathology of human haemoglobin. Nature 219:902–909.

Prokop, A., and G. Uhlenbruck. 1969. Human blood and serum groups (J. L. Raven, translator). John Wiley & Sons, New York, N.Y.

Race, R. R., and R. Sanger. 1968. Blood groups in man. 5th ed. Blackwell Scientific Publications, Oxford, England.

Wiener, A. S. 1967. Elements of blood group nomenclature with special reference to the Rh-Hr blood types. J. Amer. Med. Ass. 199:985–989.

World Health Organization. 1965. Notation for genetic factors of human immunoglobulins. Bull. World Health Organ. 33:721–724.

World Health Organization. 1967. Nomenclature of glucose-6-phosphate dehydrogenase in man. Bull. World Health Organ. 36:319–322.

PHYSIOLOGY

Most fields of physiology employ systems of symbols and abbrevations that have developed informally but have gained wide acceptance and use. Many of these symbols and abbreviations are listed in Chapter 12. Examples of their application can be found in authoritative textbooks and monographs, such as sections of the *Handbook of Physiology* (1959–1968) published by the American Physiological Society. In two fields, thermal physiology and respiratory physiology, coherent but

Table 2. Symbols for principal physical quantities and abbreviations for units of measurement associated with thermal physiology (Hardy 1969).

Symbol	Quantity	Unit of measurement	Abbreviation
α	absorptance (radiation)	ND	
A	area	square meter	m^2
k	conductivity, thermal	watt per meter per degree Celsius	W/(m•°C)
ρ	density	kilogram per cubic meter	kg/m^3
ϵ	emittance (radiation)	ND	
H	heat, rate of exchange	watt per square meter	W/m^2
λ	heat, latent	joule per kilogram	J/kg
J	heat, quantity (energy)	joule	J
h	heat transfer coefficient (total surface conductance)	watt per square meter per degree Celsius	W/(m^2 • °C)
I	irradiance (incident radiant flux density)	watt per square meter	W/m^2
L	length	meter	m
m	mass	kilogram	kg
$\dot{m}$	mass transfer rate	kilogram per second	kg/s
P	pressure	newton per square meter or millimeter of mercury	N/m^2 mm Hg
ρ	reflectance (radiation)	ND	
R; I	resistance, thermal (insulation)	degree Celsius per square meter per watt	(°C•m^2)/W
c	specific heat	joule per kilogram per degree Celsius	J/(kg•°C)
t	time	second	s
T	temperature	kelvin degree Celsius	K °C
τ	transmittance (radiation)	ND	
$\dot{V}$	ventilation rate	cubic meter per second; liter per second	m^3/s; l/s
v	velocity, linear	meter per second	m/s
V	volume	cubic meter, liter, milliliter	m^3, l, ml
W	work rate	watt, joule per second	W, J/s

Table 3. Symbols for variables in respiratory physiology. Based on "Standardization of Definitions and Symbols in Respiratory Physiology" Pappenheimer (1950).

Symbol		Definition
Gas variables	V	volume of gas
General symbols (capitals)	$\dot{V}$	volume per unit of time
	P	pressure
	F	fractional concentration in dry gas phase (% concentration/100)
	R	respiratory exchange ratio (volume CO_2)/(volume O_2)
	D	diffusing capacity in general (volume per unit of time per unit of pressure difference)
Gas variables	I	inspired gas
Modifying symbols (small capitals)	E	expired gas
	A	alveolar gas
	T	tidal gas
	D	dead space gas
	B	barometric (pressure)
Blood variables	Q	volume of blood
General symbols (capitals)	$\dot{Q}$	blood volume per unit of time
	C	concentration of gas in blood phase
	S	percentage of saturation of hemoglobin with O_2

(Continued)

independent systems of standards have been formally proposed and published.

THERMAL PHYSIOLOGY

The proposed system in thermal physiology was published (Hardy 1969) after review by an international group of investigators. Its basis is the International System of Units (SI). The symbols comprise three main groups: principal physical quantities (Table 2), physical subscripts, and physiological subscripts.

Table 3. *Continued*

Symbol		Definition
Blood variables Modifying symbols (lowercase)	a	arterial blood
	v	venous blood
	c	capillary blood
	b	blood in general
	pl	plasma
	va	venous admixture
Other modifying symbols and abbreviations (small capitals or lowercase, as shown)	bar (¯) above a symbol	a mean value
	Dot (·) above a symbol	a time derivative
	f	respiratory frequency (breaths per unit time)
	s	shunt
	m	alveolar capillary membrane
	L	lung
	th	thorax
	ti	tissue
	aw	airway
	STPD	standard temperature, pressure, dry (0°C, 760 mm Hg)
	BTPS	body temperature, pressure, saturated with water vapor
	ATP	ambient temperature, pressure, and humidity
	ATPD	ambient temperature, pressure, dry
	ATPS	ambient temperature, pressure, saturated with water vapor

Most of the physical subscript symbols are lowercase Latin letters: a, ambient; k, conductive; c, convective; D, diffusion; i, emitting source; e, evaporative; P, pressure (constant); p, projected; r, radiation (radiative); j, receiving surface; λ, spectral wavelength; V, volume (constant); w, water vapor; wb, water bulb.

All the physiological subscript symbols are lowercase letters: ar, arterial; b, body; bl, blood; es, esophageal; ex, expired; hy, hypothalamic; in, inspired; m, muscle; or, oral; re, rectal; s, skin; ty, tympanic; ve, venous.

Symbols for complex terms are built up from the three groups; for example, temperature of expired (ex) air is represented by T_{ex}, projected (p) area by A_p. The same symbols are sometimes suggested for two different quantities; such common usage is acceptable only when confusion is not likely to result. If non-SI units seem appropriate for a particular readership, the SI equivalents should be provided for readers accustomed to metric units and terms. A dot over a symbol denotes time rate of change; a bar over a symbol denotes mean value of the quantity.

Symbols to be used in equations for body-heat balance were included in the journal article mentioned above (Hardy 1969), which describes additional derived symbols and their use in special applications in thermal physiology.

RESPIRATORY PHYSIOLOGY

Symbols and abbreviations currently used in respiratory physiology were developed first for descriptions of human pulmonary function; they are applicable in respiratory physiology of infrahuman vertebrates.

Symbols for specific variables and equations for interrelated variables should be based on the system of symbols listed in Table 3. Capital letters denote general variables, such as volume and pressure; small capital and lowercase symbols denote anatomical location, molecular species, or special conditions.

Anatomical localization for a gas phase is denoted by small capital letters following the general symbol. For example, pressure in alveolar gas should be designated by $P\text{A}$. The same arrangement is followed for the blood phase, but with lowercase letters: for example, Pa for pressure in arterial blood. The molecular species is designated with the conventional chemical symbol in small capitals ($P\text{CO}_2$ is pressure of carbon dioxide), but, if both localization and molecular species are to be given, the chemical symbol is subscript to the anatomical symbol. ($P\text{A}_{\text{CO}_2}$ is pressure of carbon dioxide in the alveolar gas phase). The use of the subscript (which increases the cost of setting type) may be avoided by combined use of the descriptive term and the symbol; for example, alveolar pressure of carbon dioxide can be written as alveolar P_{CO_2} instead of $P_{A_{CO_2}}$. A dot placed above the symbol for a quantity denotes a time derivative of the quantity; thus V indicates gas volume; $\dot{V}$ indicates gas volume per unit of time (Table 3). Somewhat different but related conventions are used in British journals (Anon. 1966:14).

Special abbreviations are available for terms applied to clinical measurements of pulmonary function (for definitions and further explanation see Kory et al. 1963). British conventions differ in details (Gandevia and Hugh-Jones 1957).

LITERATURE CITED IN THIS SECTION

Anonymous. 1966. Suggestions to authors. J. Physiol. (London) 182:1–33.

Gandevia, B., and P. Hugh-Jones. 1957. Terminology for measurements of ventilatory capacity: a report to the Thoracic Society. Thorax 12:290–293.

Handbook of Physiology. 1959–1968. American Physiological Society, Washington, D.C. (A continuing series of monographs published in sections, as many as five volumes in a section. Titles of sections published: neurophysiology, circulation, respiration, adaptation to environment, adipose tissue, alimentary canal.)

Hardy, J. D., chairman. 1969. Proposed standard system of symbols for thermal physiology. J. Appl. Physiol. 27:439–446.

Kory, R. C., J. Rankin, G. L. Snider, and J. F. Tomasefski. 1963. Clinical spirometry. Dis. Chest 43:214–219.

Pappenheimer, J. R., chairman. 1950. Standardization of definitions and symbols in respiratory physiology. Fed. Proc. 9:602–605.

EXPERIMENTAL MATERIALS

Plant or animal materials used in experiments should be described precisely and completely. The ability of one investigator to confirm the findings of another may depend on the use of an identical kind of plant, animal, tissue, or cell. Detailed recommendations for descriptions of cell lines in animal tissue culture and of experimental animals have been issued by several authorities.

ANIMAL TISSUE CULTURE

The Tissue Culture Association (Fedoroff 1967) has defined usage of the most important terms in animal tissue culture. It recommends that the report of a new cell line should include the following information: the nature of the tissue of origin (whether normal or neoplastic and, if neoplastic, whether benign or malignant; whether adult or embryonic); animal species, sex, age, and organ of original cell type; designation of the cell line; and whether the line has been cloned. The designation of the line should consist of not more than four letters indicating the laboratory of origin, followed by the numbers assigned to the line.

A description of a line should present all available information about the cells. It may include history of the cell line, subculture number, culture medium, growth characteristics, absolute plating efficiency, morphology, frequency of cells with various chromosome numbers, karyotype characteristics of the stem line, sterility tests (for mycoplasmas, bacteria, fungi), confirmation of the species of origin of the culture, and virus susceptibility of the culture at a given subculture number.

A description of a cell strain should include the procedure of isolation, detailed properties of the cells, the number of subcultures, the length of time since isolation, and a full description of the cell line or primary culture from which the strain was isolated.

When a previously described cell line or strain is referred to in a publication, its origin (species and tissue) should be included with its accepted designation (rabbit kidney cells, line XY 126). A repository of characterized cells is available to investigators (American Type Culture Collection 1964). Instructions for submitting new cell lines for characterization have been published by Stulberg et al. (1970).

ANIMALS

Animals used in experiments should be clearly identified by descriptions that include stock source (or strain, if inbred) and other factors that determine their characteristics. Recommendations for full descriptions of outbred laboratory animal stocks by a literal-numerical symbol system have been published by the Institute of Laboratory Animal Resources (Poiley 1970).

The arrangement of characters in the description of an outbred animal begins with one capital and two or more lowercase letters to represent the name of the organization or individual that bred or supplied the animal. Following these letters and a colon are symbols (one or more capitals and numerals) representing current and basic stock designations; these are followed by capital letters in parentheses to represent the original stock. Next come lowercase letters to indicate rearing by means other than natural mother (fostered, f; ova transplant, e; ovary transplant, o; hand-reared, h), and then capital letters for environmental factors (gnotobiote, GN; specific pathogen-free, SPF; conventional rearing, CV; barrier rearing, BR). Abbreviations for names of suppliers and stocks are listed in *Animals for Research* (Institute of Laboratory Animal Resources 1971); the stocks include common domestic laboratory animals (fowl, rodents, dogs, cats, cattle, goats, sheep, swine, horses, ponies) and animals obtained from nature (protozoans through chordates). A hypothetical example: the High Quality Farm produces A5 rats of Sprague-Dawley descendants that are derived surgically and are hand-reared in isolators; offspring from these animals are made available to investigators as gnotobiotes; these gnotobiotic offspring are designated as Hqf:A5(SD)hGN.

Recommendations for similarly precise descriptions of farm animals have been issued by the British Society of Animal Production (1967) in two mimeographed sheets. They specify that each class of animal under discussion in a paper should, at first mention, be clearly defined in terms of species, breed or cross, sex; age, physiological state, and agricultural function; the class may be referred to in subsequent mention by a single descriptive term. Species may be designated by common terms (cattle, sheep, goat, pig or swine, horse, fowl, turkey, duck, goose). For English usage, the breed names recommended by Mason (1970) should be used and reproduced in full—for example, British Friesian or Holstein-Friesian, not Friesian.

LITERATURE CITED IN THIS SECTION

American Type Culture Collection. 1964. Registry of animal cell lines certified by the Cell Culture Collection Committee. Supplements (1965, 1967) to the first edition. U. S. Public Health Service.

British Society of Animal Production. 1967. The description of farm animals in scientific publications. West of Scotland Agricultural College, Auchincruive, Ayr.

Fedoroff, S. 1967. Proposed usage of animal tissue culture terms. J. Nat. Cancer Inst. 38:607–11.

Institute of Laboratory Animal Resources, National Research Council. 1971. Animals for research: a directory of sources of laboratory animals, fluids, tissues, organs, 8th ed. revised. National Academy of Sciences, Washington, D.C.

Mason, I. L. 1970. A world dictionary of livestock breeds, types and varieties. Tech. Commun. 8 (revised) of the Commonwealth Bur. of Anim. Breeding and Genet., Edinburgh. Commonwealth Agric. Bureaux, Farnham Royal, Slough, Bucks, England.

Poiley, S. M., chairman. 1970. A nomenclatural system for outbred animals. Lab. Anim. Care 20:903–906.

Stulberg, C. S., L. L. Coriell, A. J. Kniazeff, and J. E. Shannon. 1970. The animal cell culture collection. In Vitro 5:1–16.

CHEMISTRY AND BIOCHEMISTRY

In the United States and Canada, the authority for the names of chemical compounds is *Chemical Abstracts* and its indexes, notably the "Keyword Subject Index" in each issue; the *Subject Index* published semiannually; the *Formula Index* published semiannually with the *Index of Ring Systems* and the *HAIC* (Hetero-Atom-In-Context) *Index;* and the collective indexes, the last of which is the *Seventh* (Chemical Abstracts Service 1969–1970*a* and 1969–1970*b*). The authority for biochemical terminology and other information is the *Handbook of Biochemistry* (Sober 1970).

NONPROPRIETARY NAMES

The full chemical name of a complex substance, especially an organic compound, should be given the first time the substance is mentioned in an article, unless the generic or trivial name is well known and understood. The name need not be repeated, but good judgment is required in selecting another name, which should be nonproprietary (orotic acid serves better than uracil-6-carboxylic acid or whey factor, and phenol better than carbolic acid). Usually, if no distinction between an organic acid and its salt is needed, the *ate* form is both correct and appropriate (orotate, citrate, folate). Such usage is recommended, especially in adjectival phrases (orotate-requiring, *not* orotic acid-requiring).

Many nonproprietary names, though not derived under the rules of chemical nomenclature, are current and useful: trivial names, some of them derived from trade names (aspirin, cellophane, DDT, 2,4-D); source names, referring to the origin of the compounds (parathyroid hormone, digitalis); and coinages to suggest chemical structure (methoxychlor).

Principles that should be followed in devising nonproprietary names for pharmaceutical substances have been published by the Expert Committee on Nonproprietary Names for Pharmaceutical Preparations (1970), by the United States Adopted Names Council (USAN Council 1971), and by the American Medical Association (Anon. 1970). Names that are to be submitted to either the World Health Organization or the USAN Council for review and possible acceptance should be prepared in accord with the recommendations of the reviewing organization. Special criteria for names for antibiotics in the United States have been drafted by the American Society for Microbiology Committee on Nomenclature of Antibiotics (1967).

PROPRIETARY NAMES

Normally, a trade name should not be used for a chemical compound; it is the official trademark of the registering manufacturer. If it is necessary for identifying the product employed, it should be spelled out and capitalized as specified in the registration (Vaseline, Adrenalin).

Confusion may occur when a registered trademark in one country is a nonproprietary name in another. Thus, "Adrenalin" is a trade name for epinephrine (generic name) in the United States, and "adrenaline" is the generic name in Great Britain.

Nonproprietary (chemical, generic, trivial, and source names) and proprietary (trade) names can be found in the most recent editions of *United States Adopted Names* (USAN Council 1967, 1971), *U.S. Pharmacopeia* (United States Pharmacopeial Convention, Inc., 1965), *Pharmacological and Chemical Synonyms* (Marler 1967), *The Merck Index* (Stecher 1968), *American Drug Index* (Wilson and Jones 1971), or lists of common names accepted by national scientific societies, for example, names of insecticides as approved by the Entomological Society of America (Billings 1970 and Kenaga and Allison 1969).

ABBREVIATIONS

See also Chapter 12

Many abbreviations for long or complex names of organic compounds are acceptable: for example, NADP for nicotinamide adenine dinucleotide phosphate, and EDTA for ethylenediaminetetraacetate (IUPAC-IUB Combined Commission on Biochemical Nomenclature 1966). Such abbreviations save space, but they should be used with discretion to avoid monotony through overuse. A compound can be referred to occasionally as *it, this compound,* or, in the examples above, *the phosphate* and *the acetate.*

SYMBOLS AND FORMULAS

The *Handbook of Chemistry and Physics* (Weast 1970–1971) or *The Merck Index* (Stecher 1968) should be consulted for confirmation of chemical symbols and formulas that may be used in text, tables, or illustrations as shorthand designations (Mg, Mn, HCl, CO_2, C_2H_5OH). When merely naming a salt or specifying its concentration in a solution, use its simplest formula (Na_2SO_4, KCl, $FeCl_3$); when mentioning quantities of ordinarily hydrated salts, indicate the full molecular formula ($BaCl_2 \cdot 2H_2O$ or $K_4Fe(CN)_6 \cdot 3H_2O$). Ionic state may be indicated by adding symbols for the charge (Mg^{2+}, $SO_4{}^{2-}$, H^+, Cl^-, CH_3COO^-). Molecules of gases may be denoted by their formulas (H_2, O_2, N_2).

The oxidation state of an element may be written in roman numerals on the line and in parentheses, for example, Cr(III). The proportions of the constituents in the formula of a compound also may be indicated indirectly by Stock's System, that is, by a roman numeral in parentheses immediately after the name: dilead(II) lead(IV) oxide. When used in conjunction with a symbol, the roman numeral may be shown as a superscript: $Pb^{II}{}_2Pb^{IV}O_4$. For zeros and nonintegers, arabic numerals are substituted for roman (IUPAC Commission on the Nomenclature of Inorganic Chemistry 1960).

To denote an acid containing 18 carbon atoms, write C_{18} acid; to denote the carbon atom numbered 3, write C-3. Write $C_{18:1}$, $C_{18:2}$, $C_{18:3}$, etc., to indicate the number of double bonds in an unsaturated acid.

Avoid using a chemical symbol that can be mistaken for a word, particularly in beginning a sentence (*As* in these samples . . . *He* was present in . . . *I* was vaporized . . .). Avoid ambiguous formulas that indicate only composition; for example, C_2H_6O might be ethyl alcohol (C_2H_5OH) or methyl ether (CH_3OCH_3), and $C_4H_4O_2$ may be one of several structures.

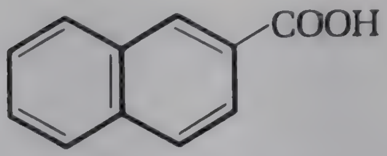
For formulas that can be typewritten, include only the most important chemical bonds and indicate them by hyphens (not by diagonal lines or arrows). Leucine, for example, may be written $(CH_3)_2\text{-}CH\text{-}CH_2\text{-}CH(NH_2)\text{-}COOH$. Should there be no need to show linkages, the formula could be written without bond symbols, thus: $(CH_3)_2CHCH_2CH(NH_2)COOH$.

Center each typed formula at an appropriate place between lines of text, leaving quadruple space above and below. Where structures of organic substances are important, type or draw the formulas to show every significant detail.

Formulas too complex to be typewritten are too complex to be set in type. For these formulas provide well-designed, black-ink drawings suitable for reproduction by photoengraving. Indicate the desired location of each drawing by a circled note in the margin of the manuscript as on page 170 (see "Indicating Positions for Figures and Tables," Chapter 6).

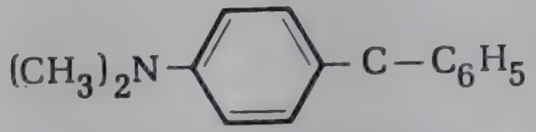
If you refer frequently to substances with complex structures and difficult names, draw the structures, labeling each with its proper name and an arabic numeral, as in Fig. 1, and then refer to each one in the text by substance and number as labeled (acid 4, ketone 9).

4.



2-Naphthoic acid

9.



p-Dimethylaminobenzophenone

Fig. 1. Structural formulas. To prepare copy for these formulas, use a template for a ring; draw or hand-letter labels in black ink, or type them. See the last paragraph on page 99 for citing formulas in text.

NUCLIDES AND ISOTOPES

The ionic charge, number of atoms, atomic number, and mass number (atomic weight) characterizing the nuclide of an element are indicated by four indices placed around the symbol. Thus $^{32}_{16}S^{2+}_{2}$ represents, in clockwise order, a doubly ionized molecule of positive charge containing two atoms of sulfur, each having atomic number 16 and mass number 32 (IUPAC Commission on the Nomenclature of Inorganic Chemistry 1960).

A radioactive nuclide is indicated by its mass number placed as a superscript to the left of the symbol (^{32}P); when written out, it should correspond to the spoken word (phosphorus-32). In an isotopically labeled compound, the isotopic prefix in brackets precedes the part of the name to which it refers; thus $^{32}PCl_3$ would be [^{32}P] phosphorus trichloride. When more than one position in a substance is labeled by means of the same isotope, the number of labeled atoms is added as a subscript to the right, as in [$^{14}C_2$]glycolic acid. If the position of the labeled element is known, it is indicated by an arabic numeral or by an appropriate italic prefix: [1-^{14}C]acetic acid; [2-^{14}C]acetic acid; [3-^{14}C,2,3-^{2}H,^{15}N]serine; [*carboxy*-^{14}C]leucine; L-[*methyl*-^{14}C]-methionine. If the position of the labeling is unknown, the indication is omitted, for example, [^{14}C]glucose; if labeling is uniform or general, the indication is [U-^{14}C]glucose or [G-^{14}C]-

glucose. The superscript mass number of an isotope is never attached to a letter in an abbreviation, but precedes the entire abbreviation: $[^{32}P]AMP$, not $AM^{32}P$ (American Chemical Society 1967).

EQUATIONS

A chemical equation should be centered between the right and left margins of the manuscript page, and quadruple space should be left above and below it. If an equation represents an equilibrium, a double arrow is shown; if the reaction goes to completion, a single arrow. In presenting biochemical reactions, authors frequently use the names of compounds rather than the complex formulas. Accepted abbreviations may be used. For example, a reaction catalyzed by an enzyme found in mammalian liver may be written as follows:

$$\text{D-xylulose} + \text{ATP} \rightarrow \text{D-xylulose 5-phosphate} + \text{ADP}$$

In general, chemical equations, like mathematical equations, should balance. For indicating the course of a reaction influenced by a catalyst or specific reagent, the following is appropriate:

$$\text{fructose} \xrightarrow{\text{hexokinase}} \text{fructose-6-P} \xrightleftharpoons[\text{hexosediphosphatase}]{\text{phosphofructokinase}} \text{fructose-1,6-P}_2$$

or further abbreviated

$$\text{Fru} \xrightarrow{\text{hexokinase}} \text{Fru-6-P} \xrightleftharpoons[\text{hexosediphosphatase}]{\text{phosphofructokinase}} \text{Fru-1,6-P}_2$$

WATER OF HYDRATION

References to quantities of inorganic salts or hydrated organic substances should specify the number of molecules of water of hydration per molecule of compound: copper sulfate pentahydrate ($CuSO_4 \cdot 5H_2O$), sodium sulfate decahydrate ($Na_2SO_4 \cdot 10H_2O$), asparagine monohydrate ($C_4H_8N_2O_3 \cdot H_2O$), amygdalin trihydrate ($C_{20}H_{27}NO_{11} \cdot 3H_2O$).

CONFIGURATION AND ROTATION

Many names of organic substances include locant numbers and letters, or syllables designating details of the chemical structure. They should be transcribed accurately. There are several isomers of dinitrophenol, for instance, and the one used must be clearly identified. In general, configurational relationships are indicated by capital italic letter prefixes *R* and *S*. This *RS* system is based on the actual three-dimensional formulas of the compound (Cahn 1964). In carbohydrate and amino acid nomenclature, configurational relationships are denoted by the small capital prefixes D and L.

Direction of optical rotation is indicated by writing dextrorotatory L-alanine, for example, as L-(+)-alanine. Rotation alone without regard to configuration in substances other than carbohydrates or amino acids may be indicated by an italic prefix *d* or *l*. Italics should be used for the symbols of elements that occur as locants in the names of many organic compounds (*O*-methyltyrosine, *S*-benzyl-*N*-phthaloylcysteine).

SOLUTIONS

The concentration of a solution is expressed in chemical terms, that is, either in normality (N) or molarity (M); the N or M is preceded by a number (0.1 N hydrochloric acid, *not* N/10 hydrochloric acid). Some biochemistry journals use N for normal and M for molar. Use only a sufficient number of decimal places to indicate the accuracy with which the solution was prepared or standardized (0.502 N hydrochloric acid). For extremely dilute solutions, use the form 1.0 μM or 1.0×10^{-6} M.

The distinctions between a mole (the molecular or formula weight in grams) and solution concentrations (molar, molal, normal) should be clear. A molar (M) solution contains 1 mole of solute in 1,000 ml of solution; a molal (mol/kg) solution contains 1 mole of solute dissolved in 1,000 g of solvent; and a normal (N) solution contains 1 gram-equivalent of the solute in 1,000 ml of solution.

The chemical definition of concentration is preferred to the percentage expression, which is frequently ambiguous. However, if you use a percentage, specify the exact chemical substance weighed or measured, and whether by weight and volume (wt/vol) or by volume only (vol/vol). Dilutions of ethyl alcohol, for instance, are usually made from commercial alcohol of density 0.816, which has a concentration of 92.3% by weight and 94.9% by volume.

ANALYTICAL AND OTHER METHODS

If in your analysis of compounds you followed an analytical or procedural method that is not widely known, cite the article in which the method was originally described. If you used an important modification of a fundamental method, name or explain it: for example, "I determined nitrogen by the Kjeldahl method as modified by Hiller et al. 1948." If the modification was trivial, cite only the article describing the fundamental method. If your method was original, at least in part, describe it briefly, avoiding inconsequential details. Since analytical chemists invariably use distilled or deionized water, you need not mention it unless specially purified water was essential.

Report analytical results in the following conventional form:

Analysis: $C_{17}H_{20}N_4O_4$; calculated: C, 59.29; H, 5.85; N, 16.27
found: C, 58.8; H, 6.03; N, 16.2

Note the punctuation, the omission of the percentage symbol, and the omission of a value for oxygen, which can be determined by adding the percentages for the known elements and subtracting from 100. Give percentages generally with one or two digits to the right of the decimal.

PHYSICAL PROPERTIES

Report the data on physical properties in the following standard form, indicating special conditions of measurement:

Melting point: mp 140–142°C (unc), (cor), (copper block), (sealed tube)
Boiling point: bp 120°C at 15 mm
Specific refractive index: $[n]_D^{16} = 1.4767$
Specific rotation: $[\alpha]_D^{22} = -20 \pm 2°$ (1.0 M in water)

Record temperature, wavelength of light (λ) used in measuring specific rotation, solvent, and concentration of solute. You may obtain molecular rotation by multiplying the specific rotation by the molecular weight of the solute: $[M]_\lambda$ = (molecular wt/100)$[\alpha]_\lambda$. For macromolecules, the mean residue rotation (m) is often given: $[m]_\lambda$ = (mean residue wt/100)$[\alpha]_\lambda$.

Statements of melting points should indicate whether you applied a correction for stem emergence of the thermometer. If you make no statement about method, the reader will assume that the substance was heated in an open tube immersed in a suitable bath. Avoid the ambiguous term *mixed melting point* by writing, "The compound examined had a mp 178–179°C (unc), an authentic sample had a mp 179–180°C (unc), and when the two were combined the melting point of the mixture was 177–179°C (unc)." Record boiling points at atmospheric pressure unless you state otherwise.

SPECTROPHOTOMETRY

In reporting spectrophotometric data, indicate the relation between the symbols used. The transmittance, as expressed by T, is I/I_0. Here I is the intensity (or power) of radiation, of wavelength λ, after passing through a cell, of optical path length l, containing an absorbing solute; I_0 is the intensity (or power) transmitted by a carefully matched cell, also of length l, containing solvent only; the intensity (or power) of the incident beam is the same for both cells. The absorbance, A (which is identical with the extinction E), is defined by the relation $A = -\log_{10}T = \epsilon lc$, where l is the length of the optical path in centimeters, c is the concentration of the absorbing substance in moles per liter, and ϵ is its molar absorptivity (molar extinction coefficient). By this definition the dimensions of ϵ are $\text{liter} \cdot \text{mole}^{-1} \cdot \text{cm}^{-1}$. The wavelength λ, or frequency ν, of the radiation should always be specified, and the value of ϵ at wavelength λ may be written as ϵ_λ (ASTM 1966).

CENTRIFUGING

When conditions for centrifuging are critical, sufficient information should be given to enable another investigator to repeat the procedure; the make of centrifuge, rotor used, temperature, time at maximum speed, and centrifugal force should be stated.

In reporting ultracentrifuge data, give sedimentation and diffusion measurements, including the temperatures at which they were made. The appropriate abbreviations are s, sedimentation coefficient; $s_{20,w}$, sedimentation coefficient corrected to 20°C in water; s^0, sedimentation coefficient at zero concentration; S, Svedberg unit of sedimentation coefficient (S = 0.1 picosecond or 10^{-13} second); $\bar{v}$, partial specific volume; D, $D_{20,w}$, D^0, diffusion coefficients corresponding to sedimentation coefficients.

CHROMATOGRAPHY

Chromatographic evidence for identity and purity may be presented by a photograph or by a black-ink tracing of the paper. State the kind of paper, the solvent(s), the conditions, and the R_f values of all components present, together with those of authentic materials. Note that R_f means the ratio of the movement of the substance to that of the solvent front, and that R is an italic letter and the f a subscript italic letter; also that the process is chromatography, and the paper and its spots are a chromatogram, not a chromatograph. Avoid such neologisms as *papergram.* A chemist does not elute (or extract) *the spots,* nor does he extract *the paper;* he elutes or extracts *the substance from the paper.* In column chromatography, he does not pool, titrate, or mix *the tubes,* but he does pool, titrate, or mix *the fractions in,* or *the contents of, the tubes.*

METABOLIC QUOTIENTS

The symbol Q_x represents metabolic quotient in microliters of gas X per milligram dry weight of biological material per hour only. Metabolic quotients in any other units of measurement (micromoles of X per milligram N per second) are symbolized by q_x. When first mentioned, the units for Q or q must be clearly defined. If the metabolite X is a solid or a liquid, it is conventionally considered a gas at normal temperature and pressure (NTP), 1 micromole of X being equivalent to 22.4 microliters.

Superscript symbols should be used to indicate aerobic conditions, as $Q^{O_2}_{CO_2}$ or $q^{O_2}_{CO_2}$, and anaerobic conditions, as $Q^{N_2}_{CO_2}$ or $q^{N_2}_{CO_2}$. The substrate may be shown in parentheses, for example, $Q^{N_2}_{CO_2}$ (pyruvate), which written out would read, "microliters of carbon dioxide produced anaerobically from pyruvate per milligram dry tissue per hour." Production or consumption can be indicated by + or − quotients, for example $+Q_{CO_2}$.

The symbols Q_x or q_x may be omitted if the units of measurement are given whenever a quotient is mentioned.

ENZYMES

Enzyme names and Enzyme Commission (EC) numbers published in *Enzyme Nomenclature* (International Union of Biochemistry 1965) are recommended, as in the example D-glucose-6-phosphate:NADP oxidoreductase (EC 1.1.1.49), which is the systematic name and number of an enzyme. However, the recommended trivial name is also acceptable if the identifying number is included, thus: glucose-6-phosphate dehydrogenase (EC 1.1.1.49). Both systematic and trivial enzyme names are listed in the index of *Enzyme Nomenclature*.

RIBONUCLEIC ACID

Fractions or functions of ribonucleic acids (RNA) are frequently designated by prefixes (mRNA for messenger RNA; rRNA for ribosomal RNA; nRNA for nuclear RNA; and tRNA for transfer RNA—formerly called "soluble" RNA and designated sRNA).

The tRNA that combines with a particular amino acid, glycine for example, is written glycine tRNA (abbreviated, tRNA^{Gly}). When the glycine tRNA has become attached to a glycyl residue, it is called glycyl-tRNA (with a hyphen as indicated), abbreviated Gly-tRNA. Such a matched tRNA attached to its cognate amino acid is generally referred to as an aminoacyl-tRNA. A mismatch, such as glycine tRNA attaching to alanine, would be written $\text{Ala-tRNA}^{\text{Gly}}$.

If there is more than one specifying or accepting tRNA, each may be designated by a subscript arabic numeral: $\text{tRNA}_1^{\text{Ala}}$ and $\text{tRNA}_2^{\text{Ala}}$; these are "isoacceptors." The source of the tRNA is written tRNA^{Ala} (*Escherichia coli*) or (*Escherichia coli*) tRNA^{Ala}. Aminoacyl-tRNA's are familiarly referred to as "charged," and the specifying tRNA is called "stripped," but these terms should be avoided. See IUPAC-IUB Commission on Biochemical Nomenclature 1970.

POLYPEPTIDES AND OTHER POLYMERS

In polypeptides and proteins, constituent amino acids are designated by three-letter symbols, which are usually the first three letters of the trivial names. These symbols, which represent the names of the radicals and their structural formulas, should not be used in written text for the free amino acids, but they are acceptable for this purpose in tables, diagrams, or figures where space is limited. Their chief use is in structural representation of polypeptides and proteins. The accepted abbreviations (or symbols) for the common amino acids are as follows:

Ala, alanine
Arg, arginine
Asn, asparagine
Asp, aspartic acid
Asx, asparagine or
  aspartic acid
Cys, cysteine
|
Cys (or Cys), cystine
  (half) |
Gln, glutamine
Glu, glutamic acid
Glx, glutamine or
  glutamic acid
Gly, glycine
His, histidine
Hyl, hydroxylysine
Hyp, hydroxyproline
Ile, isoleucine
Leu, leucine
Lys, lysine
Met, methionine
Orn, ornithine
Phe, phenylalanine
Pro, proline
Ser, serine
Thr, threonine
Trp (not Try), tryptophan
Tyr, tyrosine
Val, valine

An example of a tripeptide, glycyllysylalanine, in abbreviated form is Gly-Lys-Ala (each hyphen represents a peptide bond). Generally amino acid residues (except glycine) are assumed to be of the levo (L) configuration, unless the contrary is explicitly indicated. (The accepted abbreviation for a common amino acid is the same as that for the residue; for example, Ala represents alanine, and, in polypeptides, it represents the residue, alanyl.) For a detailed discussion of designations of amino acid derivatives and peptides, see IUPAC-IUB Commission on Biochemical Nomenclature 1966.

The left end of the polypeptide or protein is, by convention, the amino terminal and is written NH_2-terminal (rather than N-terminal). The right portion is designated the carboxy terminal and is written COOH-terminal (rather than C-terminal). Amino acids (as residues) in peptides or protein sequences can be numbered from left to right. A portion of a protein (partial sequence) might then be designated or identified by numbers and symbols, for example, His^{23} to Ala^{35}. See IUPAC-IUB Commission on Biochemical Nomenclature 1967*a* for further information.

Hyphens and commas between the symbols for amino acid residues have special meanings. Hyphens indicate a known sequence, as in Ala-Leu-Lys. Unknown sequences are enclosed in parentheses and are separated by commas as in (Gly,Phe, Tyr). Vertical strokes indicate the covalent bonding of functional groups (as in half-cystine residue in the list above) or the remaining hydrogen atom of the peptide bond.

Special conventions are applied in characterizing the structures of synthetic polypeptides. The simple homopolymer, polyalanine, is designated poly Ala or (Ala)$_n$. For a linear copolymer of random sequence whose composition is unknown, write poly DLAla,Lys or (DLAla,Lys)$_n$. For a linear copolymer of alternating sequence and unknown composition, write poly DLAla-Lys or (DLAla-Lys)$_n$. For a linear sequence of unknown order with known composition, indicate the percentage of each with superscripts, poly Glu^{56}Tyr^{44} or (Glu^{56}Tyr^{44})$_n$; the information (Glu is DL, Tyr is L) may be added. For extensions of the foregoing usage to block polymers and graft polymers, consult IUPAC-IUB Combined Commission on Biochemical Nomenclature 1968.

Synthetic polyribonucleotides may also be designated by the "poly" system. For example, polyadenylate is poly A; poly (adenylate-uridylate), alternating sequence, is poly (A-U); and poly(adenylate, uridylate), random sequence, is poly (A,U). For polydeoxyribonucleotides (poly dN), the position of the deoxy is optional; write poly (dA-dT) to indicate poly(deoxyadenylate-deoxythymidylate), or poly d(A-T) to indicate poly deoxy(adenylate-thymidylate). Composition and size may be shown by appropriate subscripts as in (A$_2$,U$_1$)$_{50}$, which contains 100 A's and 50 U's in random sequence, and in d(A-T)$_{50}$, which contains 50 dA's and 50 dT's in regular alternating sequence.

Associated polynucleotides (guanine and cytosine, for example) are shown as poly(G)·poly(C), or, if the two chains are of equal length, as $G_n \cdot C_n$. Similarly, a base pair of nucleotides is shown with a raised period to indicate association (G·C), a hyphen to indicate a sequence (G-C), and a plus sign to indicate content (G + C content was 28%). Nucleotide sequences of codons may be written without separating punctuation (UAU or CAG or UGG).

The individual elements of a polynucleotide are written with a connecting hyphen. A lowercase p may be used on the left end of the sequence to indicate a terminal 5′-phosphate (pA-G-A), and on the right end to indicate a terminal 3′-phosphate (A-U-Gp). Left to right direction is implied, unless an arrow is used in place of the hyphen to indicate reverse direction: A-U-Gp can be written pG←U←A. See IUPAC-IUB Commission on Biochemical Nomenclature 1970 for additional information.

CARBOHYDRATES

Monosaccharide units and their residues in oligosaccharides and polysaccharides may be indicated in tables, lists, and figures by the following abbreviations:

Gal, galactose
Glc, glucose
Fru, fructose
Man, mannose
Rib, ribose
Xyl, xylose

Other monosaccharides are similarly represented by the first three letters of their respective names, unless confusion with an existing symbol (Gly and Thr in the amino acid series) would result.

A 2-deoxy sugar is designated by the symbol for its most common parent sugar with the prefix d (dRib for 2-deoxyribose). Other deoxy sugars may be designated similarly with a positional numeral (3-dGlc for 3-deoxyglucose).

Pyranose and furanose forms are designated where necessary by the suffixes *p* and *f*. Configurational symbols D and L (small capital letters) and anomeric prefixes are shown where necessary as prefixes (Glc*p* or αDGlc*p* for an α-D-glucopyranose unit; Fru*f* or βDFru*f* for a β-D-fructofuranose unit). Symbols thus formed are joined by hyphens to indicate the links between units. The position and nature of the links are shown by numerals and the anomeric symbols α and β thus:

Maltose, Glc*p*α1-4Glc
Lactose, Gal*p*β1-4Glc
Stachyose, Gal*p*α1-6Gal*p*α1-6Gal*p*α1-2βFru*f*

Arrows may be used to indicate the direction of the glycoside link, the arrow pointing away from the hemiacetal carbon of the link; for example, lactose may be represented as Gal*p*β1→4Glc.

Derived monosaccharide units may be designated by the addition of modifying suffixes. To indicate an aldonic acid, add A

(GlcA for gluconic acid); for uronic acids, add UA (GalUA for galacturonic acid). To indicate a 1-amino-2-deoxysaccharide, add the suffix N to the parent saccharide symbol (GalN for galactosamine); an *N*-acetyl derivative is shown by NAc (GalNAc for *N*-acetylgalactosamine). See IUPAC-IUB Combined Commission on Biochemical Nomenclature 1966.

LIPIDS

The rules for lipid nomenclature are too complex to summarize here. The official recommendations of the IUPAC-IUB Commission on Biochemical Nomenclature (1967*b*) should be consulted.

STEROIDS

The rules for steroid nomenclature are far too complex to summarize here. The official recommendations of the IUPAC Commission on the Nomenclature of Organic Chemistry and the IUPAC-IUB Commission on Biochemical Nomenclature (1969) should be consulted.

REPRINTS

Reprints of the IUPAC-IUB Commission on Biochemical Nomenclature (CBN) publications can be obtained from Dr. Waldo E. Cohn, Director, NAS-NRC Office of Biochemical Nomenclature (OBN), c/o Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37830.

LITERATURE CITED IN THIS SECTION

American Chemical Society. 1967. Handbook for authors. American Chemical Society Publications, Washington, D.C.

American Society for Microbiology. Committee on Nomenclature of Antibiotics. 1967. Statement concerning the use of names for antibiotics in the USA. Bull. World Health Org. 37:151–152.

Anonymous. 1970. Guiding principles for coining US adopted names for drugs. J. Amer. Med. Ass. 213:608–610.

ASTM (American Society for Testing Materials). 1966. Manual on recommended practices in spectrophotometry. American Society for Testing Materials, Philadelphia, Pa.

Billings, S. C., chairman. 1970. Consolidated list of approved common names of insecticides and certain other pesticides. Bull. Entomol. Soc. Amer. 11:204–213. ("Additions to the listings" were published in 1966 under the title "Announcement of the Insecticide Terminology Committee." Bull. Entomol. Soc. Amer. 12:356–357.)

Cahn, R. S. 1964. An introduction to the sequence rule. A system for the specification of absolute configuration. J. Chem. Educ. 41:116–125.

Chemical Abstracts Service. 1969–1970*a*. Chemical Abstracts seventh collective index, volumes 56–65, 1962–1966. Formulas. 4 vols. American Chemical Society, Washington, D.C.

———. 1969–1970*b*. Chemical Abstracts seventh collective index, vols. 56–65, 1962–1966. Subjects. 13 vols. American Chemical Society, Washington, D.C.

Expert Committee on Nonproprietary Names for Pharmaceutical Preparations. 1970. General principles for guidance in devising international nonproprietary names for pharmaceutical substances. WHO [World Health Organ.] Chron. 24:141–142.

International Union of Biochemistry. 1965. Enzyme nomenclature. American Elsevier Publishing Co., New York, N.Y.

IUPAC [International Union of Pure and Applied Chemistry] Commission on the Nomenclature of Inorganic Chemistry. 1960. Nomenclature of inorganic chemistry. J. Amer. Chem. Soc. 82:5523–5544.

IUPAC-IUB [International Union of Pure and Applied Chemistry-International Union of Biochemistry] Combined Commission on Biochemical Nomenclature. 1966. Abbreviations and symbols for chemical names of special interest in biological chemistry. Revised tentative rules. J. Biol. Chem. 241:527–533.

———. 1968. Abbreviated nomenclature of synthetic polypeptides. (Polymerized amino acids.) Tentative rules. J. Biol. Chem. 243:2451–2453.

IUPAC-IUB Commission on Biochemical Nomenclature. 1966. Abbreviated designation of amino acid derivatives and peptides. Tentative rules. J. Biol. Chem. 241:2491–2495.

———. 1967*a*. Rules for naming synthetic modifications of natural peptides. Tentative rules. J. Biol. Chem. 242:555–557.

———. 1967*b*. The nomenclature of lipids. J. Biol. Chem. 242:4845–4849.

———. 1970. Abbreviations and symbols for nucleic acids, polynucleotides and their constitutents. J. Biol. Chem. 245:5171–5176.

IUPAC Commission on the Nomenclature of Organic Chemistry and the IUPAC-IUB Commission on Biochemical Nomenclature. 1969. IUPAC-IUB revised tentative rules for nomenclature of steroids. Biochemistry 8:2227–2242.

Kenaga, E. E., and W. E. Allison. 1969. Commercial and experimental organic insecticides (1969 revision). Bull. Entomol. Soc. Amer. 15:85–148.

Marler, E. E. J. 1967. Pharmacological and chemical synonyms. 4th ed. Excerpta Medica Foundation, New York, N.Y.

Sober, H. A., editor. 1970. Handbook of biochemistry. Selected data for molecular biology. 2nd ed. Chemical Rubber Co., Cleveland, Ohio.

Stecher, P. G., editor. 1968. The Merck index. 8th ed. Merck and Co., Rahway, N.J.

United States Pharmacopeial Convention, Inc. 1965. The pharmacopeia of the United States of America (the United States pharmacopeia), 17th rev. Mack, Easton, Penna.

USAN Council (United States Adopted Names Council). 1967. United States adopted names (USAN): a compilation of the United States adopted names (USAN) selected and released from June 15, 1961, through December 31, 1966. United States Pharmacopeia, Rockville, Md.

———. 1971. United States adopted names (USAN): a compilation of the United States adopted names (USAN) selected and released from January 1, 1967, through December 31, 1970. United States Pharmacopeia, Rockville, Md. [This publication contains as Appendix III, pp. 74–79, "Guiding principles for coining U.S. adopted names for drugs."]

Weast, R. C., editor. 1970–1971. Handbook of chemistry and physics. 51st ed. Chemical Rubber Co., Cleveland, Ohio.

Wilson, C. O., and T. E. Jones. [Annual publication.] American drug index. J. B. Lippincott, Philadelphia, Pa.

MATHEMATICAL FORMULAS AND EQUATIONS

In preparing mathematical copy for typesetting, be precise about alignment of numerals, letters, and symbols; hand-letter any that cannot be typewritten.

IDENTIFYING CHARACTERS

Some letters, numerals, and other characters are apt to be ambiguous to a printer, especially when they stand alone. In typewritten copy, ambiguity may occur in the use of 1 (one or el), 0 (zero or oh), × (multiplication sign or ex), Greek letters, script letters, diacritical marks, and prime. Identify any possibly ambiguous character by a circled notation in the nearest margin. In some handwritten copy, capitals (especially C, K, O, P, S, U, V, W, X, Z) are hardly distinguishable from lowercase letters. Identify letters not clearly capital or lowercase. Indicate a capital letter by three underlines; indicate a lowercase letter by marking it "lc."

Indicate a subscript by a caret above the character, and a superscript by an inverted caret below the character, marked in ink of another color than black.

USING ITALICS

Although the editor is responsible for instructing the printer about the use of italics in mathematical equations, every author should know accepted practices. With certain exceptions, single letters in equations are italicized. Chemical symbols, abbreviations of more than a single letter (ln, avg, max), and numbers are not italicized. If you use an abbreviation that is not standard, explain it in the text or legend.

SIMPLIFYING EQUATIONS

Use the simplest form of equation that can be made by ordinary mathematical calculation. Although a bar fraction (cross-rule) is acceptable in a centered (displayed) equation, avoid using this form of fraction in a line of text. Substitute a solidus for the bar. This will enable the fraction to fit within the text line without projecting above or below it. Each of the recommended forms of notation in Fig. 2 can be set on one line; any of the forms not recommended require more than one line and are difficult and expensive to set in type. See page 114.

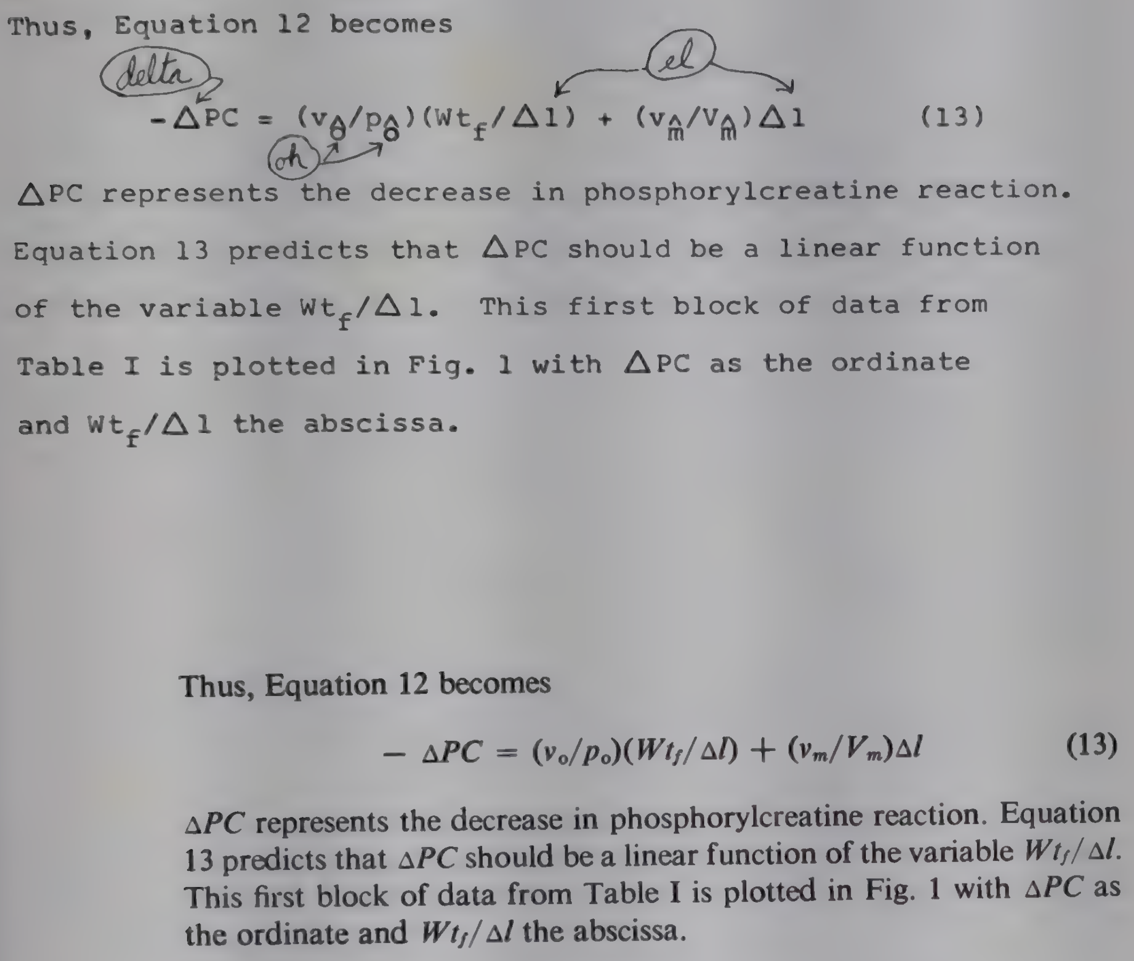
PRESENTING COMPLEX EQUATIONS

Center (display) complex equations between left and right margins of the manuscript page; leave generous space above and below. Number each equation; place the number in parentheses near the right margin of the page.

The editor or the printer will decide how to break equations that exceed page or column width in the journal. He may run to page width an equation that exceeds the width of a single

Form of notation	Not recommended (typewritten)	Recommended (typewritten)	Recommended (in type)
One-line fraction	$\frac{a + b}{2}$	$\frac{1}{2}(a + b)$ or $0.5(a + b)$	$\frac{1}{2}(a + b)$ or $0.5(a + b)$
Fractional exponent	$a\sqrt{bc}$	$a(bc)^{\frac{1}{2}}$ or $a(bc)^{0.5}$	$a(bc)^{1/2}$ or $a(bc)^{0.5}$
Slant line (solidus)	$\frac{a + b}{x + y}$	$(a + b)/(x + y)$	$(a + b)/(x + y)$
Negative exponent	$a = \frac{2g \sin B}{3R}$	$a = 2/3(R^{-1}g) \sin B$ or $a = 0.66R^{-1}g \sin B$	$a = \frac{2}{3}(R^{-1}g) \sin B$ or $a = 0.66R^{-1}g \sin B$
Pointed brackets instead of bar to designate average	$\overline{a + b}$	$\langle a + b \rangle$	$\langle a + b \rangle$
Exponential function	$Ae^{\frac{1}{2}(V_o/D)}$	$A \exp \frac{1}{2}(V_o/D)$ or $A \exp 0.5(V_o/D)$	$A \exp \frac{1}{2} (V_o/D)$ or $A \exp 0.5 (V_o/D)$
Superior over inferior	x_a^2	$x_a{}^2$	$X_a{}^2$

Fig. 2. Mathematical formulas. Forms in the second column are not recommended; they are difficult and expensive to set in type. The recommended equivalents in the third column require only one line apiece.



Thus, Equation 12 becomes

$$\overset{\text{delta}}{-\Delta} PC = (v_{\underset{\text{oh}}{\hat{o}}}/p_{\hat{o}})(Wt_f/\Delta \overset{\text{el}}{1}) + (v_{\hat{m}}/V_{\hat{m}})\Delta \overset{\text{el}}{1} \qquad (13)$$

ΔPC represents the decrease in phosphorylcreatine reaction. Equation 13 predicts that ΔPC should be a linear function of the variable $Wt_f/\Delta 1$. This first block of data from Table I is plotted in Fig. 1 with ΔPC as the ordinate and $Wt_f/\Delta 1$ the abscissa.

Thus, Equation 12 becomes

$$-\Delta PC = (v_o/p_o)(Wt_f/\Delta l) + (v_m/V_m)\Delta l \qquad (13)$$

ΔPC represents the decrease in phosphorylcreatine reaction. Equation 13 predicts that ΔPC should be a linear function of the variable $Wt_f/\Delta l$. This first block of data from Table I is plotted in Fig. 1 with ΔPC as the ordinate and $Wt_f/\Delta l$ the abscissa.

Fig. 3. Typewritten copy from an author, copy-edited and marked for the compositor by author or editor; below it, the same copy set in type.

column. If one of your equations exceeds the width of a manuscript page, break it before a sign of operation, which should begin the runover line. When several breaks are necessary and the equation contains few signs of operation, arrange the components in logical sequence.

If an equation cannot be reproduced entirely by typewriter, you may type the characters that are available and complete the equation with lines, symbols, and other characters drawn with black ink. The editor or the printer will usually decide whether the equation can be set entirely in type or whether it can be better rendered as a cut made from a combination of typeset letters and hand-drawn symbols and lines.

Figure 3 shows well-marked typewritten copy from an author and also the copy after it has been set in type.

STATISTICS

Data should be analyzed and summarized by statistical methods appropriate to the design of the experiment or survey from which the data were derived. The design should be briefly and clearly described.

Statistical methods commonly used in the biological sciences do not require presentation of mathematical formulas or bibliographic references. Those infrequently used need not be described in detail, but adequate references should be given to them.

Standard designs are adequately described by name and size, for example, "a 6 × 6 Latin square." For a factorial set of treatments, an adequate description might be merely

> Trytophan at 0.05 or 0.10 percent of the diet and niacin at 5, 10, or 20 mg per kg of diet were used in a 2 × 3 factorial plan arranged in a 6 × 6 Latin square with six animals per plot.

For the report of a drug study having a completely randomized design, the following description of the design might suffice:

> Two hundred male patients were randomly divided into two groups, a control group and a treatment group. The division was determined

by the last digit of the hospital admission number; patients whose numbers ended with an even digit were assigned to the control group and those with numbers ending in odd digits to the treatment group. Each treatment patient was given 2.0-gram aspirin tablets every 4 hours; each control patient was given the same number of lactose tablets, identical in appearance to the aspirin tablets, in the same schedule.

Emphasize biology, not statistics. A simple statement of the results of statistical analysis should justify the interpretations and conclusions. Do not report a number of similar experiments separately. Adequate reporting may require only (i) the number of data, *n;* (ii) the arithmetic mean, $\bar{x}$; and (iii) the standard deviation, SD, or the standard error of the mean, SE. Such information may be included in text or table, as 324 ± 5.8 (27), in which the first two numbers show the mean plus or minus the standard deviation or standard error (indicate which), and the third number (in parentheses) represents the number of data. If the mean is presented with plus or minus two standard deviations, this information should be given.

Standard deviation refers to the variability in a sample or a population. Standard error (calculated from error variance) is the estimated sampling error of a statistic such as the sample mean. When a standard deviation or standard error is given, the number of degrees of freedom on which it rests should be stated. When any statistical value (as mean or difference of two means) is mentioned, its standard error or confidence limits should usually be given.

For analyses of variance and covariance, a statement of subclass means and their standard errors is insufficient. A table of sources of variation presents concisely many additional items such as mean squares attributable to blocks or to treatment main effects or interactions, and the error mean square(s), with their respective numbers of degrees of freedom.

Give only meaningful digits. A practical rule in statistics is to round so that the change caused by rounding is less than one-tenth of the standard error. Such rounding increases the variance of the reported statistic by less than 1 percent, sacrificing less than 1 percent of the relevant information the data contain. This rule is exemplified in the third preceding paragraph, for the statistic and for its standard error.

Conventions in statistical abbreviations vary among authorities. Table 4 presents some of the most frequently used symbols and abbreviations for some statistical parameters. Greek letters are used for population parameters and Roman or Latin letters for sample statistics (the estimates of parameters obtained from samples of the populations).

Computer print-out of data and pertinent statistical analyses may be suitable as manuscript or typesetter's copy and, if properly planned, may be adequate for photographic reproduction and printing. Use of such print-out may reduce errors in transcription of data into typescript.

Useful references on statistics include Cochran and Cox 1957, Fisher and Yates 1963, and Snedecor and Cochran 1967.

Table 4. Some symbols and abbreviations currently used in statistics.

Population parameters	Sample statistics	Explanation
	n, N	total number of individuals or variates
μ		mean of the population
	$\bar{x}$	arithmetic mean of the sample
σ		standard deviation of the population
	s, SD, or SD	standard deviation of the sample
σ^2		variance of the population
	s^2	sample variance
	$s_{\bar{x}}$, SE, or SE	standard error of mean of sample
	C.V.	coefficient of variation
	t	statistical datum derived in Student's *t-test*
	χ^2	statistical datum derived in the chi-square test
	p, P	probability of wrongfully rejecting the null hypothesis (level of significance)
β		regression coefficient of population
	r	coefficient of correlation, sample
	R	coefficient of multiple correlation
	F	variance ratio

LITERATURE CITED IN THIS SECTION

Cochran, W. G., and G. M. Cox. 1957. Experimental designs. 2nd ed. John Wiley & Sons, New York, N.Y. (Exposition of many designs as to characteristics, uses, and analysis of variance.)

Fisher, R. A., and F. Yates. 1963. Statistical tables for biological, agricultural, and medical research. 6th ed. Hafner Publishing Co., New York, N.Y. (Statistical and other tables suitable for ordinary problems of design of experiments and analysis of data.)

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods. 6th ed. Iowa State University Press, Ames, Iowa. (A basic textbook of applied statistics.)

GEOGRAPHY AND GEOLOGY

For the accepted form and spelling of a geographic name, refer to the *Style Manual* of the U.S. Government Printing Office (1967), the *Lexicon of Geologic Names of the United States for 1936–1960* (Keroher 1966), or the lists published periodically by the Board on Geographic Names, Office of Geography, U.S. Department of the Interior.

Write a geologic name or term in accordance with the stratigraphic records of the Geologic Names Committee, U.S. Geological Survey. Table 5 shows the accepted names for eras, systems or periods, and series or epochs, and also the standard letter symbols used on geologic maps.

Capitalize the following and similar words when they designate any of the great soil groups:

Alpine Meadow Bog Chernozem
Desert Podzol Prairie Tundra

Do not capitalize the name of a minor stratigraphic unit or a name used only locally:

formation dome coal bed slate
fault Oklahoma oil fields currelly vein

A publication issued by the U.S. Geological Survey (1958) contains many suggestions helpful to authors of papers in geology and related fields.

Table 5. Major stratigraphic and geologic time divisions in use by geologists in the United States.

Era	System or period		Series or epoch	Approximate beginning time (millions of years ago)
	Name	Symbol		
Cenozoic	Quaternary	Q	Holocene (Recent)	.006
			Pleistocene (Glacial)	2
	Tertiary	T	Pliocene	10
			Miocene	23
			Oligocene	34
			Eocene	50
			Paleocene	70
Mesozoic	Cretaceous	K	Upper, Lower	135
	Jurassic	J	Upper, Middle, Lower	180
	Triassic	T_R	Upper, Middle, Lower	200
Paleozoic	Permian	P		270
	Pennsylvanian	ℙ*	Upper, Middle, Lower	320
	Mississippian	M*	Upper, Lower	350
	Devonian	D	Upper, Middle, Lower	400
	Silurian	S	Upper, Middle, Lower	430
	Ordovician	O	Upper, Middle, Lower	490
	Cambrian	Є	Upper, Middle, Lower	600
Precambrian		pЄ	Upper, Middle, Lower	4,500

* The letter symbol C is used to designate Carboniferous systems in regions where Pennsylvanian and Mississippian systems are not differentiated.

LITERATURE CITED IN THIS SECTION

Keroher, G. C., and others. 1966. Lexicon of geologic names of the United States for 1936–1960. U.S. Geol. Surv. Bull. 1200. Part 1, A–F; Part 2, G–O; Part 3, P–Z.

U.S. Geological Survey. 1958. Suggestions to authors of the reports of the United States Geological Survey. 5th ed. U.S. Government Printing Office, Washington, D.C.

U.S. Government Printing Office. 1967. Style manual. Rev. ed. U.S. Government Printing Office, Washington, D.C.

Table 6. Greek alphabet with Latin and English equivalents.

Name of letter	Capital	Lowercase	Latin and English equivalent
alpha	Α	α	a
beta	Β	β	b
gamma	Γ	γ	g (*or* n)
delta	Δ	δ	d
epsilon	Ε	ϵ	e
zeta	Ζ	ζ	z
eta	Η	η	ē
theta	Θ	θ	th (*or* t)
iota	Ι	ι	i
kappa	Κ	κ	k (*or* c)
lambda	Λ	λ	l
mu	Μ	μ	m
nu	Ν	ν	n
xi	Ξ	ξ	x
omicron	Ο	ο	o
pi	Π	π	p
rho	Ρ	ρ	r (*or* rh)
sigma	Σ	σ, ς	s
tau	Τ	τ	t
upsilon	Υ	υ	y (*or* u)
phi	Φ	ϕ	ph (*or* f)
chi	Χ	χ	ch (*or* kh)
psi	Ψ	ψ	ps
omega	Ω	ω	ō

Table 7. Transliteration of the modern Russian alphabet as revised by Standards Committee Z39 of the American National Standards Institute.

Letter number	Russian printed		Transliteration	Example	
1	а	А	a	адрес	— adres
2	б	Б	b	баба	— baba
3	в	В	v	вы	— vy
4	г	Г	g	голова	— golova
5	д	Д	d	да	— da
6[*]	е(ё)	Е(Ё)	e(ë)	ещё	— eshchë
7[†‡]	ж	Ж	zh	журнал	— zhurnal
8	з	З	z	звезда	— zvezda
9	и	И	i	книга	— kniga
10[†]	й	Й	ĭ	первый	— pervyĭ
11	к	К	k	как	— kak
12	л	Л	l	липа	— lipa
13	м	М	m	муж	— muzh
14	н	Н	n	нижнйй	— nizhniĭ
15	о	О	o	общество	— obshchestvo
16	п	П	p	пара	— para
17	р	Р	r	рыба	— ryba
18	с	С	s	сестра	— sestra
19	т	Т	t	товарищ	— tovarishch
20	у	У	u	утро	— utro

Table 7. Transliteration of the modern Russian alphabet, (concluded)

Letter number	Russian printed		Transliteration	Example	
21	ф	Ф	f	физика	– fizika
22[†]	х	Х	kh	химический	– khimicheskiĭ
23[†‡]	ц	Ц	ts[§]	центральный	– tsentral’nyĭ
24[†‡]	ч	Ч	ch	часы	– chasy
25[†‡]	ш	Ш	sh	школа	– shkola
26[†‡]	щ	Щ	shch	щит	– shchit
27	ъ	Ъ	”	объявление	– ob”yavlenie
28	ы	Ы	y	был	– byl
29	ь	Ь	’	белье	– bel’e
30	э	Э	ė	это	– ėto
31[†‡]	ю	Ю	yu	южный	– yuzhnyĭ
32[†‡]	я	Я	ya	яйцо	– yaĭtso

[*] Cyrillic ë should not be transliterated by ë unless the diacritical mark appears in the original.

[†] In countries where tradition favors it, the following variations are permitted, but only as a group:

Letter 7 : Ж – ž
10 : Й – j
22 : Х – h
23 : Ц – c
24 : Ч – č
25 : Ш – š
26 : Щ – šč
31 : Ю – ju
32 : Я – ja

[‡] When a proper name beginning with one of these Cyrillic letters is abbreviated to the initial letter, the two-letter transliteration should be a capital followed by a lowercase letter; for example, capital letter 32 is transliterated by Ya.

[§] When Cyrillic letter 19 is followed by Cyrillic letter 18 the transliteration is t · s or, if it is at the beginning of a sentence or a proper noun, T · s.

5. Preparation of Copy

INTRODUCTION

The final draft of your article, the typescript you mail to the journal editor, should contain few, if any, corrections. Therefore, the work of bringing your text and miscellaneous material into conformity with the journal style and checking data and references against original sources should have been done before typing of the final draft is begun.

This chapter presents instructions for preparing copy that will be acceptable to most biological journals. Additional instructions will probably be found in a recent issue of the journal to which you plan to send your manuscript. Where differences occur, the instructions in the journal should take precedence.

Familiarize yourself with the information in this chapter before you begin writing, even though it may not seem relevant to you at that time. Some items, including those about tables and figures, should receive your early and close attention or the attention of other persons—statistician, draftsman, artist, photographer. Later, while working on the copy from which the final draft will be typed, review this chapter item by item.

Arrange in order the pages from which the final draft will be typed and read them with meticulous care, looking especially for typographical errors. Pay particular attention to quotations, citations, technical terms, names of persons and places, and numerical data in text and tables. Check each item in the bibliographic section against the original article or book for name(s) of author(s), wording and spelling of title, name of journal or publisher, volume, pages, and other details; do not depend on citations by other authors, on reprints, or on your own rough notes.

Check or recheck the title, tables, illustrations, and other parts of your manuscript against the directions given in this chapter and in the journal for which you are writing. Make changes neatly and legibly on the copy from which the final draft will be typed (see Chapter 6).

TITLE

Before typing of the final draft is begun, reexamine the title you have tentatively chosen for your article (see page 2). Remember that the title should clearly represent the contents of the article and the research reported. Titles are widely used by scientists searching the literature of specific areas. Moreover, they are important to indexing services of libraries and to institutions having mechanical or electronic literature-retrieval systems.

The title for your final draft should precisely identify the main topic of your paper. It should be informative, specific, and concise. It may appropriately include the name of the experimental organism used and the technical approach (as morphology, histochemistry, demography).

One effective way to construct a title is to begin with a significant word or phrase and follow it with descriptive words that distinguish specifically the material of the article.

Another way is to write a short, one-sentence summary of your results, for example:

Laboratory White Mice Acquire Immunity to *Fasciola hepatica* within Four Generations

Below are examples of well-constructed titles of journal articles:

Pineal Gland: Influence on Gonads of Male Rats Treated with Androgen Three Days after Birth

Alarm Pheromone in the Earthworm *Lumbricus terrestris*
Acquired Immunity to *Fasciola hepatica* in the Laboratory White Mouse
Inhibition of Rat Brain Tryptophan Hydroxylase by 6-Halotryptophans

The following phrases and others like them, although common, are superfluous and therefore ought not to be used in titles: *studies on, preliminary studies on, contributions to, investigations on.*

Four titles that violate the principles of good construction are the following:

Further Studies on the Erythrocyte Anti-Inflammatory Assay
Notes on Amphibian Parasites
Opuscula miscellanea nematologica IX
LDH-Isoenzymes in Infarcted Heart Muscle

The first two titles contain superfluous words. The second and third are so general that they have insufficient meaning for a reader searching the literature. The fourth, from a nonclinical journal, fails to specify the host or the animal involved.

Many journals capitalize titles as in the examples given above. A copy editor will mark your title to make it conform to the style of the journal publishing your article.

BY-LINE

See also page 2

The by-line for an article normally comprises two elements: (i) the name(s) of the author(s)—that is, the person or persons who contributed *materially* to the research being reported—and (ii) the name(s) of the institution(s) where the research was done. Follow the by-line style in a recent issue of your journal.

Be consistent about the given name(s) or initial(s) you use in the by-lines of your articles. (If you spell out one or more of your given names in some articles and use only initials in others you may cause confusion in the literature.) Omit titles and degrees unless the journal makes a practice of including them. Give the name of the department and institution in which the research you are reporting was done and add the mailing address of the institution, including zip code; spell out the name of the state.

In the event that you are no longer at the institution where the research was done, include your current address for correspondence and requests for reprints.

The by-line style for an article having several authors from several institutions may be difficult to ascertain. The responsibility of authors is to list their names and respective institutions in such a way that the editor can unmistakably associate each author with his institution.

Do not give credit in the by-line for technical assistance. A person thus credited may be cited incorrectly as an author.

ABSTRACT

After you have completed the first draft of your article, examine the tentative abstract (see page 2) to determine whether it meets the requirements of the journal to which you will send it. Most journals specializing in primary publication of the results of experimental research prefer, and even insist on (for any but a review article), the *informative abstract,* a succinct condensation of the contents of the abstracted article; this abstract should include the purpose of the research, the methodology, results, and conclusions. Most journals specializing in review articles prefer the *indicative abstract,* a kind of expanded table of contents that contains generalized statements and directs the reader to the abstracted article for qualitative and quantitative data.

If you are reporting original research, and are writing an informative abstract, identify in the abstract, as you did in the title, the main topic of your paper. Also, state the basic reason for doing the research reported, indicate the method(s) used, list material(s) studied, and briefly summarize the results and conclusions. Do not merely describe or recite the contents of your article:

Activity of largemouth bass at various times of day is discussed.

Instead, tell what you did and what you found:

Largemouth bass were most active between the hours of 0900 and 1100.

When published with your article, the abstract should provide readers with a helpful preview; when published separately, it should give them a broad, if not deep, acquaintance with your reported research.

An abstract published separately from a supporting paper must not be used for proposing a new taxon. It does not meet the specifications of clear, precise, and complete definition required by the rules of botanical, zoological, and bacteriological nomenclature. A name proposed in an abstract published without a supporting paper is a *nomen nudum* and has no validity.

Make certain that your abstract is of a length permitted by the journal (usually not more than 250 words) and that it contains no elliptical or incomplete sentences and no abbreviations or terms that might confuse readers in disciplines other than your own. It should not contain illustrations or tables, or references to them or to the literature. It should be typed double-spaced on a separate sheet of paper or, unless the journal gives other instructions, with the key words.

If the abstract is for an article by one author, it should be headed by his name, with the family name preceding the given name(s) or initial(s), his current address in parentheses, the title of the article, and the journal name. Space should be left for later insertion of volume number, pages, and date of publication.

If the abstract is for an article by more than one author, it should be headed similarly except that, for most journals, the family and given name(s) or initial(s) of only the first author are interchanged. If all authors have the same current address, it is given after the final name. If authors have different current addresses, generally the address of only the first author is given, as in the example below:

Ricklefs, Robert E. (Smithson. Trop. Res. Inst., Balboa, Canal Zone), and F. Reed Hainsworth. Temperature dependent behavior of the cactus wren. Ecology [space for volume number, pages, and date of publication, followed by text of abstract].

The work reported by Ricklefs and Hainsworth was done at the University of Pennsylvania; the name of this institution was run directly below the authors' names in the by-line of the article in *Ecology.* At the time the article was published, Ricklefs was with the Smithsonian Tropical Research Institute and Hainsworth at Duke University; their current addresses were given in footnotes of the article.

Include the abstract when you submit your article for publication. The editor will insert the bibliographic details and transmit the abstract to one or more abstracting services, either in its original form (if the journal does not publish abstracts), as proof, or in a copy of the journal.

For additional information about writing abstracts see "Guide to the Preparation of Abstracts" in January issues of *Biological Abstracts* and recent reports of Subcommittee 6 of Committee Z39 of the American National Standards Institute (formerly United States of America Standards Institute).

KEY WORDS, INDEXING TERMS, OR DESCRIPTORS

Good journal practice is to publish with each article a list of about 10 key words (known also as index terms or descriptors) suitable for information-retrieval systems. The words you select for such a list may be from the title, the abstract, the body of your paper, or the thesaurus for your discipline. In making your selection, ask yourself what words you would look for if you were searching an index for the most important topics in your article. The key words may be typed on the page with the abstract.

RUNNING HEAD

Consult the requirements of the journal to ascertain whether you are expected to supply an abbreviated title to be set as a running head at the top of each right-hand page of your printed article or as a foot line at the bottom of the page. The running head for an article entitled "Morphological Differentiation and Adaptation in the Galápagos Finches" might be "Galápagos Finches." The permissible length for your running head or foot line can be determined by counting characters and spaces in running heads or foot lines of the journal.

HEADS AND SUBHEADS

See also page 8

Each journal has its own style specifications for heads and subheads. Most journal articles contain heads and subheads of two or three levels or orders of importance, each level with its distinctive typography and position with relation to text. A head or subhead may be (i) centered in a column or page, with space above and below; (ii) set flush left in a column or page; or (iii) set at the beginning of a paragraph of text (run-in sidehead). If well constructed, the hierarchy of heads and subheads serves as an easily discernible outline of the article.

Before you assume that your manuscript is ready for final typing, read your tentative heads and subheads critically, first individually in relation to the text that follows and then in relation to each other. Do they conform to the style of the journal to which you plan to send your manuscript? Are they concise, pertinent to the text, and similar in tone and grammatical construction? Does each have the correct relationship to the text that follows?

A common fault is to follow a subhead directly by a pronoun referring to a word or phrase in the subhead:

Medicinal Uses of Plants. They . . . .

A less serious fault is to repeat the subhead itself in the sentence that follows. Position the heads and subheads in your typescript to conform to the practice of the journal. Follow the style of capitalization adopted by the journal or, if you are unable to determine it, capitalize only the first word and words that would normally be capitalized in text (a copy editor will mark the subheads to make them conform to journal style).

If the levels of importance of your heads and subheads are not apparent from their positions, identify each of them with an appropriate circled number or letter in the left-hand margin of the typed page: 1 or A for highest level, 2 or B for second level, 3 or C for third level. Or include with your manuscript a typed list of heads and subheads, indented as necessary to indicate their relative importance.

ACKNOWLEDGMENTS

See also page 8

In writing for a journal that permits an Acknowledgments section with each article, you can give credit there for grants-in-aid, illustrative material you have borrowed, and the assistance of persons who have helped you in research or in the writing of your article. If your journal carries no such section, you can acknowledge assistance in the Introduction or possibly in one or more footnotes. Keep the footnotes to a minimum.

If your article is based on a dissertation or thesis, so identify it, possibly in the Acknowledgments section or as a footnote to the Introduction.

FOOTNOTES TO TEXT

See also page 8

Unless the journal for which you are writing follows a different system of annotation, indicate a footnote to text matter by a superscript number, shown in typescript by an inverted caret: $\overset{1}{\vee}$. Number the footnotes consecutively throughout the article (or chapter of a book). Type them double-spaced on a separate sheet or sheets.

Treat each footnote as a paragraph by indenting the first line, which begins with the superscript character that relates to the citation in the text.

Some journals use a series of symbols or reference marks (*, †, ‡, §, ||, #, ¶, **, ††) to identify footnotes. In preparing your paper for such a journal, type each footnote at the bottom of the page to which it applies. Begin the series of reference marks anew with each typed page containing footnotes.

PUBLISHED AND UNPUBLISHED AUTHORITY

See also pages 4, 9, and 152

Absolute accuracy is imperative in quoting or paraphrasing published or unpublished authority to support your conclusions. Check against the original of each published reference for name(s) of author(s), date of publication, title of article (or book), name of journal (or publisher) and other bibliographic details.

Carefully read the original—not a quotation from or a paraphrase of it—in making certain you quote or paraphrase accurately. In paraphrasing, be objective in your selection of data and unbiased in your interpretation of statements. Respect the intent of the writer of the material you paraphrase. In quoting, reproduce the original exactly as to spelling, italics, and punctuation, unless you indicate to the reader in some way (for example, by inserting words within brackets) that you have made changes.

To assure the reader that you have quoted accurately, you may write *sic* in brackets immediately after misspelled words or other inaccuracies or irregularities in materials you are quoting:

"The plant had prulep [*sic*] leaves."

Or you may suggest a correction and place it in brackets:

"The plant had prulep [purple?] leaves."

If you make an insertion within a quotation, enclose it within brackets:

"by Van Slyke's [manometric] method."

Do not substitute parentheses for brackets. Parentheses enclosing your own words within another writer's statement would falsely identify your words as his. Add brackets by hand if necessary.

If you change the emphasis of all or part of a quotation, as by italics, so indicate in parentheses:

"Omit *useless* words" (italics mine).

Note that the parentheses are outside the closing quotation mark but before the period.

If you omit a word or words from a quotation, indicate the omission by spaced periods or ellipsis marks (see "Spaced Periods or Ellipsis Marks," Chapter 3).

Type all quotations and paraphrases double-spaced. Follow the rules for quotation marks given in Chapter 3.

Custom and courtesy require acknowledgment of the authorship of material you have quoted or paraphrased and the source of illustrative material you have borrowed. Courtesy also requires permission to quote even brief passages from the work of any living person. Law requires permission to quote more than a few words of copyrighted text or to reproduce a copyrighted illustration or table.

As the author of your paper, you are responsible for obtaining whatever releases are necessary. Request the releases in time to include in your typescript a notice of each in the form prescribed by the copyright owner, normally as a footnote or part of a legend.

Personal communications and interagency reports should be regarded as unpublished material. If material of this type has influenced your conclusions, use it as supporting evidence only if you have obtained written permission from the writer or the issuing organization.

Some government agencies that issue mimeographed or offset reports for limited distribution restrict use of the information presented. Most of these reports are based on incompleted research, do not represent final conclusions, and carry a warning that the information they contain is not for publication.

The contents of a personal communication and other unpublished material not in the public domain (facts and ideas as well as words) are the property of the writer and are protected by common law. You should have written permission of the writer either to quote or to paraphrase such matter.

Published material not protected by copyright is in the public domain. Copyright protection extends to the "style" (wording) of text but not to the facts or ideas expressed; also, it applies to tables as well as to maps, drawings, photographs, and other illustrative matter.

Written and illustrative material published initially by the United States Government is in the public domain and cannot be copyrighted. However, publication by the government of copyrighted matter does not abridge or annul the original copyright, and permission to quote should be obtained from the copyright owner.

What constitutes fair use of copyrighted material, or the number of words that may be quoted without permission of the copyright owner, varies with the type of material, the author, and the publisher; this subject has been the cause of many damage suits. Some publishers do not require permission except for quotations of more than 250 or 300 words.

In 1962, members of the Association of American University Presses (of which no commercial publishers are members) passed the following "Resolution on Permission."

1) That publications issued under our imprints may be quoted without specific prior permission in works of original scholarship for accurate citation of authority or for criticism, review, or evaluation, subject to the conditions listed below.
2) That appropriate credit be given in the case of each quotation.
3) That waiver of the requirement for specific permission does not extend to quotations that are complete units in themselves (as poems, letters, short stories, essays, journal articles, complete chapters or sections of books, maps, charts, graphs, tables, drawings, or other illustrative materials), in whatever form they may be reproduced; nor does the waiver extend to quotation of whatever length presented as primary material for its own sake (as in anthologies or books of readings).
4) The fact that specific permission for quoting of material may be waived under this agreement does not relieve the quoting author and publisher from the responsibility of determining "fair use" of such material.

When asking permission to use copyrighted material, identify it fully and accurately. The copyright owner is usually either the publisher or the author (or photographer or artist). In a book, the copyright notice customarily appears on the reverse side of the title page; in a periodical, it appears on the title page, the first page of text, or under the title heading of the periodical.

Permission to paraphrase copyrighted material is not required unless the paraphrase closely follows the original wording.

TABLES

See also pages 3 and 11

In preparing copy for the final draft, reexamine your tables and make necessary revisions. Have you organized the data in each table to facilitate comparisons, reveal relationships, and show trends? Have you made each table self-explanatory by means of carefully thought-out title, heads, and, where necessary, footnotes? Does the design of your tables conform to the style adopted by the journal?

Each table should utilize space efficiently. It should not include columns of data that can be calculated easily from data in other columns, unless the derived data are needed for interpretation and discussion. It should fit within either a column or a page of the journal. Few editors will accept a table requiring a foldout leaf, and many dislike a table requiring two or more pages or a broadside (a table in which the lines are run vertically on the page); hence, unless you have the consent of your editor, you should submit no table that, if set, would exceed the width of a type page.

To estimate how wide one of your tables would be if set in type, compare the number of characters and spaces in the longest line with the number of characters and spaces in a page-width table of the journal; make due allowance for each space that is wider than a character.

Study each excessively wide table to determine whether one or more columns can be deleted. Or try interchanging stub headings and boxheads; sometimes this device will produce a table that occupies less horizontal space and is more readable. Some tables that cannot be reduced enough or rearranged to fit the page may be divided into two or more smaller tables.

THE PARTS OF TABLES

Most tables in biological journals have four main parts: (i) the *number* and *title;* (ii) the *boxhead,* identifying the entries in the vertical columns; (iii) the *stub,* identifying the entries in the horizontal lines; (iv) the *field,* containing the data (Fig. 1). Many tables also have one or more *footnotes* and some a *headnote.*

TABLE NUMBERS

Early in the writing of your paper you gave your tables numbers, which should be regarded as tentative. When preparing your paper for the final draft, check your tables against the text to assure yourself that they are numbered consecutively in the order in which you want them to appear and that each table is referred to at least once in the text.

TABLE TITLES

Make certain that each table title conforms to the style adopted by the journal of your choice. Some journals use the style of title shown in Fig. 1, with or without a headnote; a headnote is convenient for giving in precise detail the conditions of an experiment carried out under a fixed and repeated set of conditions. Other journals use the style shown in Fig. 2, or a modification of it. The first "sentence" lacks a main verb; the sentences that follow, if any, are complete and contain additional information necessary to an understanding of the table—information similar to that in the headnote and some of the footnotes of Fig. 1.

CROSS RULES

Tables commonly have horizontal or cross rules: a single rule below the title, a single rule below the boxhead, a single rule below the field. Additional horizontal rules (straddle rules) may be needed in the boxhead if two or more levels of subheads are used, Fig. 1.

VERTICAL RULES

Although some biological journals use vertical rules in tables, most avoid them because of their cost; in copy set by linotype, these rules must be inserted by hand. The function of vertical rules can normally be served by straddle rules, shown in Figs. 1 and 2.

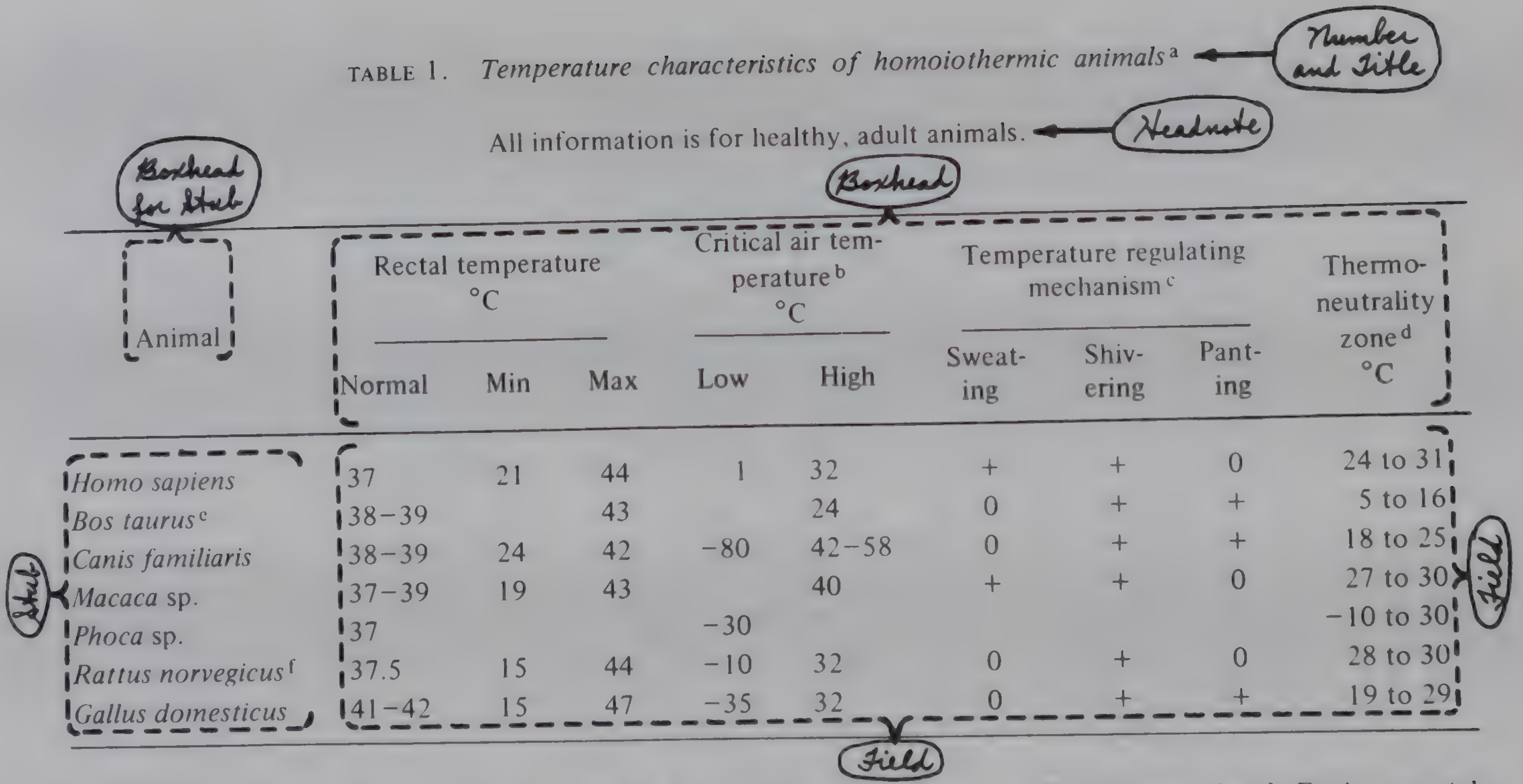


TABLE 1. *Temperature characteristics of homoiothermic animals*[a]

All information is for healthy, adult animals.

Animal	Rectal temperature °C			Critical air temperature[b] °C		Temperature regulating mechanism[c]			Thermo-neutrality zone[d] °C
	Normal	Min	Max	Low	High	Sweating	Shivering	Panting	
Homo sapiens	37	21	44	1	32	+	+	0	24 to 31
Bos taurus[e]	38–39		43		24	0	+	+	5 to 16
Canis familiaris	38–39	24	42	−80	42–58	0	+	+	18 to 25
Macaca sp.	37–39	19	43		40	+	+	0	27 to 30
Phoca sp.	37			−30					−10 to 30
Rattus norvegicus[f]	37.5	15	44	−10	32	0	+	0	28 to 30
Gallus domesticus	41–42	15	47	−35	32	0	+	+	19 to 29

[a] Adapted from original table by Ederstrom, H. E. 1966. *In* P. L. Altman and D. S. Dittmer [ed.] Environmental biology. Federation of American Societies for Experimental Biology, Bethesda, Md.

[b] Air temperature at which the normal animal first begins to show a change in deep body temperature.

[c] Symbols: + = present; 0 = absent.

[d] Range of air temperature at which the normal animal has the lowest metabolic rate.

[e] Dairy cattle.

[f] White rat.

Fig. 1. One type of table with its various parts identified.

Table 8. The numbers of mollusc species represented by living and dead material at each of the sites investigated. The 34 species represented solely by empty shells have been excluded from these totals; data are from quantitative samples only.

Site	Salt Marsh		Tidal Creeks	
	Live	Dead	Live	Dead
Westport	2	2	5	5
Pony Slough	4	3	3	3
Arcata	3	3	0*	3
Tomales Bay (Walker Creek)	2	2	2	8
Tomales Bay (Millerton)	3	3	8	10
Moss Landing†	2	2	4	9
Mugu Lagoon	4	8	7	10
Mission Bay (Total)	7	8	11	13
San Quintin Bay (North)	3	5	3	6
San Quintin Bay (Cemetery)	5	6	2	5
Black Warrior Lagoon	5	6	5	10

* An oil slick that resulted from a tugboat accident may account for the absence of live specimens.
† Unfavorable weather interfered with collecting at this site.

Fig. 2. A type of table common in biology journals. The straddle rules below "Salt Marsh and "Tidal Creeks" make vertical rules unnecessary.

ALIGNMENT IN COLUMNS

Numerical entries in table columns should be carefully aligned. If entries are unequal in length, center the longest and align the decimal points, expressed or implied (Fig. 3, column II). Place a zero before the decimal point of a number less than 1 (column VI). Do not use both minus sign and dash in a column of numbers that show a range; substitute *to* for the dash (column V). In a column in which a dash shows range, align the decimal points in the figures at left only (column IV); if *to* is used instead of a dash, align on a *to* that permits alignment of the decimal points in the numbers to right and left (column V). When standard deviations or standard errors are given, align the ± signs and then the decimal points (column VI). Leave space on each side of the ± signs.

I	II	III	IV	V	VI
60	60.5	54,321	37.5	23 to 34.5	22.3 ± 1.5
40	125.3	4,321	37.2–39	−20.8 to −10	847 ± 51
88	49.9	321	38-39	−8 to 12	8.32 ± 0.12
57	0.5	21	35.9–36.7	−1.7 to 2.8	0.64 ± 0.01

Fig. 3. Columns of numerals properly aligned. Alignment is usually on decimal points.

FACTORS IN COLUMN HEADINGS

An important purpose of tables is to allow readers to make rapid comparisons and interpretations of numerical data. You cannot contribute to the accomplishment of this purpose by presenting columns of figures with unwieldy numbers of digits, some of them meaningless and some even misleading because they imply greater precision than your research method warrants.

If, for example, you have calculated on the basis of a sample area that the number of *Andropogon gerardi* plants on Phegley hill prairie is 170,535 per hectare, you will simplify interpretation of your table, satisfy the requirements of scientific accuracy, and possibly reduce the size of your table by expressing this number as 171 or 170.5 in a column headed *thousands* (see "Reporting Numbers," Chapter 3). The value of any number in the column can be derived by multiplying the digits by the factor 1,000.

One of the advantages of the metric system is that it is adapted to eliminating needless zeros and meaningless digits in columns of figures. A number with many digits (including zeros) can, by a change of units, be readily transformed to one with fewer digits. Thus, the large number 120,000 or 120,048 grams can be expressed as 120 in a column headed *kilograms* or *kg*. The small number 0.000 000 124 gram can be expressed as 124 under the column headed *nanograms* or *ng*, or as 0.124 under the heading *micrograms* or *μg* (*microgram* if all numbers in the column are less than 1).

Except in rare instances, avoid numbers with exponents (10^3, 10^{-3}) as factors in column headings; they have been the cause of much confusion in biological literature. If you use them, treat them as you would treat *hundreds, thousands,* or *millions* in a column heading. To find the value of any number in a column, your readers should multiply the digits by the factor in the heading.

SYMBOLS AND ABBREVIATIONS

Symbols and common abbreviations may be used freely in tables if they are needed to save space (Min, Max, †, and 0 in Figs. 1 and 2).

FOOTNOTES TO TABLES

In the tables themselves an identifying letter, numeral, or reference mark (*, †, ‡, §, ||, #, ¶, **, ††) should be placed directly to the right of each item to be footnoted (as in Figs. 1 and 2). The characters are arranged in the order in which text is read: the primary direction is horizontal, from left to right, and the secondary is from top to bottom (well shown in Fig. 1). A superscript character is indicated thus: $\overset{a}{\vee}$, $\overset{1}{\vee}$, $\overset{*}{\vee}$.

Footnotes should be typed in order immediately below the table to which they apply (not on a separate sheet). Each footnote should be treated as a separate paragraph and begun with the proper identifying character, which usually is on the line, as in Fig. 2, and not superscript. Some journals run all lines of each footnote flush left; some indent the first line.

LEADERS IN TABLES

A dash or a minus sign should not be used in the field of a table to indicate a lack of data. If directional guides are needed, leaders (three or more spaced periods) should be used in each space lacking data. If data were sought without success, this fact should be indicated by the notation ND (no data) or a footnote.

TYPING OF TABLES

No more than one table should be typed on a sheet. The typing should be *double-spaced throughout,* including title, headings, and footnotes. (See Chapter 6, *The Final Draft.*)

ILLUSTRATIONS

See also pages 4 and 11

In the final selection and preparation of your illustrations (figures), scrutinize each individually and ask yourself (i) if it is really needed; (ii) if it is in the medium best suited to your purpose; (iii) if it will take the reduction necessary; (iv) if its quality meets the standards of the journal.

Discard any figure that does not contribute substantially to an understanding of your paper or that merely duplicates material in the text, a table, or another figure.

Consider the various media available for figures—photographs, wash or continuous-tone drawings, line drawings, graphs, maps. Restyle any illustration that would be more effective in some other medium. A photograph might be better than a line drawing to convey the appearance of a piece of laboratory equipment, whereas a line drawing might be better than a photograph to show essential differences between similar pieces of equipment or to suggest how to build equipment.

As your illustrations are reproduced, the proportions of each will remain constant; the size will be limited by the width and depth of the type page. Normally, an illustration will be reduced to the width of the type page or the width of a column or two columns of type. Because the cost of an engraving is based on the space the illustration will occupy on the printed page, and because cost is an important consideration in journal management, plan your illustrations so that when published they will be no larger than necessary. A reducing glass is helpful in showing you the width to which an illustration can be reduced without decreasing its effectiveness.

If you are writing for a journal having a type page of two columns, you should normally plan most of your vertical figures for one-column width, your horizontal figures for two-column. If your journal has a one-column page, you probably should avoid small vertical figures unless two or more with their legends can be grouped side by side on a page. A narrow vertical figure on a one-column page is wasteful of space if no text is run beside it. It wastes money if text is run on one or both sides, because type in narrow measure costs more than type in regular text measure.

Redo or discard illustrations of inferior quality. The figures in your article are likely to be noticed by the potential reader even before he reads the title. An unfavorable first impression created by figures of poor quality is not easily overcome.

If any of your illustrations are reproduced from the work of other authors, see "Published and Unpublished Authority," this chapter, on directions for obtaining the necessary permission and giving credit.

LINE ILLUSTRATIONS

Graphs, maps, and other illustrations consisting of lines, dots, or stippling in one tone are reproduced for letterpress printing as line engravings. For offset printing, they are reproduced by the photographic method used in reproducing text.

Draw graphs, maps, and other line illustrations with black (India) ink, or red ink, on white drawing paper or tracing vellum or on graph paper with light blue grid lines. Lines other than light blue—even green-blue or blue containing a mere trace of red—may show at least faintly in a reproduction. Make each illustration larger than you expect it to be when reproduced on the journal page—possibly twice as large.

A graph suitable for a slide to illustrate a lecture is not necessarily suitable for a figure in an article. The rough plotting and the explanatory material common in slides are inappropriate for a graph that is to be published in a scientific journal.

In preparing a graph for publication, name the variables and their corresponding units of measurement on the abscissa and ordinate as shown in Fig. 4. Incorporate most of the explanatory material in the legend. Make interval marks on both axes. Insert commas in numbers having four or more digits. Place a zero before the decimal point of a number less than 1.

Plot the points accurately and draw the curves precisely. If a point represents the mean of a number of observations, indicate the magnitude of the variability by a vertical line centered at each point. State in the legend whether the variability indicated is standard error (SE or SE) or standard deviation (SD or SD), and specify the number of observations.

Instead of making a separate graph for each curve, draw several curves on a graph whenever your data permit you to

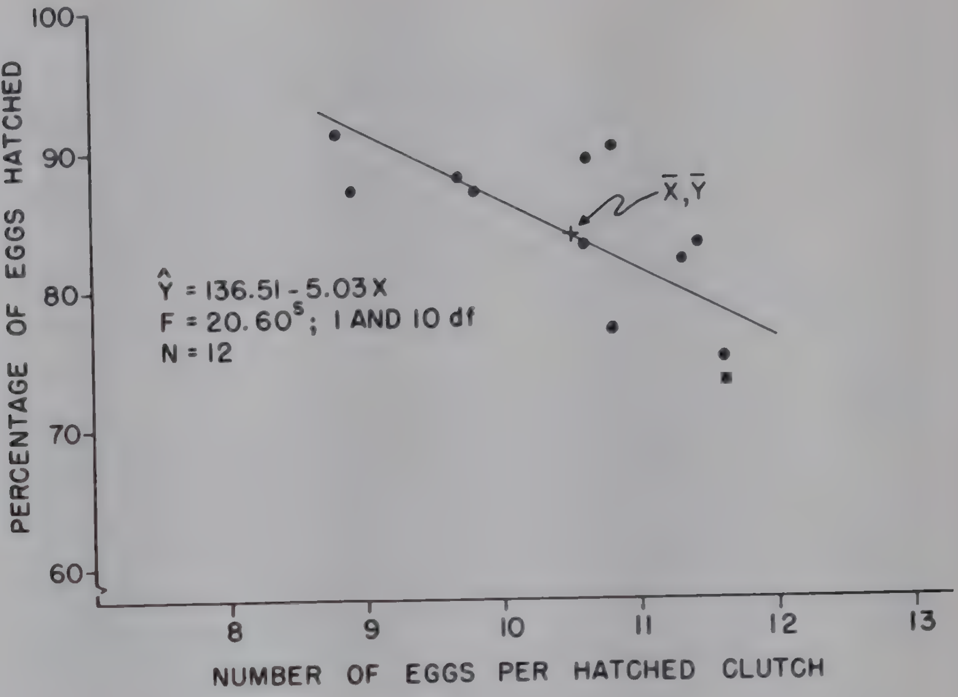


Fig. 4. Graph with legible lettering of uniform size and lines of proper weight.

do so. Draw each curve with a different kind of line (solid, dashed, dotted) or with a different symbol for the plotted points (dot, circle, square, triangle, x). Identify the curves, either by labeling each or by a key that includes all curves on the graph. If symbols are to be referred to in the text, include only those that are available to printers:

○ ● ◒ ◑ □ ■ △ ▲ ×

Make the symbols large enough and open enough to be clearly identifiable after they have been reduced in the engraving process (see "Lettering Illustrations," this chapter).

Some conventional symbols and many patterns of lines, dots, stippling, and cross-hatching are available commercially on dry-transfer or pressure-sensitive sheets. They will reproduce well if not given too great a reduction. Avoid excessively coarse, excessively fine, or distracting patterns.

On maps include such relevant information as is provided by a scale of distance, a directional indicator, and designations of latitude and longitude.

Many editors of biological journals require the originals of graphs or other line drawings. Others will accept, and some prefer, glossy photographic prints of the drawings; the prints must have sharp, precise lines, letters, numerals, and symbols. Prints that contain blurred characters or out-of-focus lines make inferior engravings. Some editors request one or more xerographic copies of each line illustration. The copies are sent to reviewers; the originals, usually heavier and possibly subject to damage in the mail, are held in the editorial office.

Oscillograms, electrocardiograms, and electrophoretic patterns are usually reproduced as line engravings. Good prints are required, preferably without grid markings. In each, the curves should be black with the background white.

PHOTOGRAPHS AND CONTINUOUS-TONE DRAWINGS

A photographic print or a continuous-tone drawing that is being reproduced for either letterpress or offset printing of a biological journal is photographed through a screen (usually 110, 120, 133, or 150 lines to the inch) that breaks up the image into dots of various sizes—small in light areas, large in dark areas. For letterpress printing, the image is transferred to a sensitized metal plate that is etched with acid to produce a relief printing surface. The etched plate, usually mounted on wood, is called a photoengraving, engraving, halftone, halftone engraving, or cut; on the press, ink is applied to the halftone engraving and transferred directly to paper. For offset printing, the image is photographed on film and transferred to a sensitized metal or plastic plate that is chemically treated to produce a surface similar to that of a halftone engraving; on the press, ink is applied to the plate and transferred first to a rubber "blanket" on a metal roller and then to paper.

In selecting photographs to illustrate your article, choose glossy prints with sharp focus and suitable contrast—prints with full range of tonal values. A common practice is to submit prints that are at least 20 by 25 cm (standard 8- by 10-inch prints are suitable). They will need to be reduced in the engraving process. Many photographs benefit from at least slight reduction. Photomicrographs and electron micrographs are reproduced most faithfully if they are not reduced.

You may submit a print that should not be cropped—every part of it is essential to an understanding of the subject. Or you may submit one that can and should be cropped—some parts of the print are extraneous and do not contribute to your purpose in using it. Indicate on such a print the areas that may be cropped. Make crop marks with a wax pencil at the edges of the print or very lightly on an overlay, a sheet of thin paper laid over the print and taped to the reverse side. Some editors prefer prints that can be cropped to those that cannot. Cropping gives an opportunity to correct faulty lines—to straighten tilted horizons or leaning buildings in the background.

Sometimes you may save space by grouping several photographs. If you wish to have the editor group and mount the prints, enclose a diagram to show the desired arrangement. If you prefer to mount the prints yourself, use dry-mounting tissue or rubber cement to affix them to stiff white cardboard or chipboard of good quality. Make certain that adjacent sides of prints form 90° angles. Unless the adjacent sides of the composite form 90° angles, the printer may shear off essential parts of your pictures when he squares up the cut.

Never combine a line drawing with a photograph in a single illustration unless you have obtained the approval of the editor; the cost of a combination line cut and halftone engraving is greater than can usually be justified.

DIMENSIONS AND SCALING

Ordinarily a sheet of art work submitted with a manuscript should be no larger than about 22 by 28 cm (8½ by 11 inches is a satisfactory size).

If you have figures that are to be reproduced without reduction, keep them within the dimensions of the journal type page, allowing space below each for its legend.

As most figures need reduction by the engraver, you will find a slide rule, an engraver's scaling device or reduction wheel (available at art supply stores), or a simple proportional equation helpful for scaling your figures—that is, for calculating either (i) the dimensions your figures will have after they have been reduced to page or column width or (ii) the dimensions required for an original figure that is to be reproduced as an engraving of a given size.

Assume you have several photographs you want to mount as a composite that (with the legend) will occupy an entire type page, the dimensions of which you know. After deciding on the width of the composite original and allowing for the space to be occupied by the legend on the page, you can use either the ratio or the equation for computing what the height of the original should be:

Reduced width : Original width : : Reduced height : Original height

$$\text{Original height} = \frac{\text{Reduced height} \times \text{Original width}}{\text{Reduced width}}$$

The type page is 12 cm wide and 18 cm deep; the space needed for the legend is 3 cm, leaving 15 cm for the height of the composite on the page. The width of the composite original is 20 cm. Your equation will be

$$12 : 20 : : 15 : x \quad \text{or} \quad x = \frac{15 \times 20}{12}$$

The height of the composite original should therefore be 25 cm.

The pica, a unit of measurement common among engravers and printers in the United States, and equal to about ⅙ inch, is convenient for making calculations like the above.

A geometrical method for finding the second dimension of a reduced illustration after the first dimension has been decided upon is shown in Fig. 5.

Some line drawings and photographs benefit from as much as 50 percent reduction. Reduction minimizes some flaws (such as slight irregularities in lines) and accentuates others (such as inadequate spacing between letters or parts of letters). Although it decreases the thickness of lines, it also decreases the distance between them, with resultant filling-in of parts of letters, numerals, and symbols improperly made or given too great a reduction, as in Fig. 6. This figure demonstrates both the results of excessive reduction and the care that must be taken in making figures that are to be reduced.

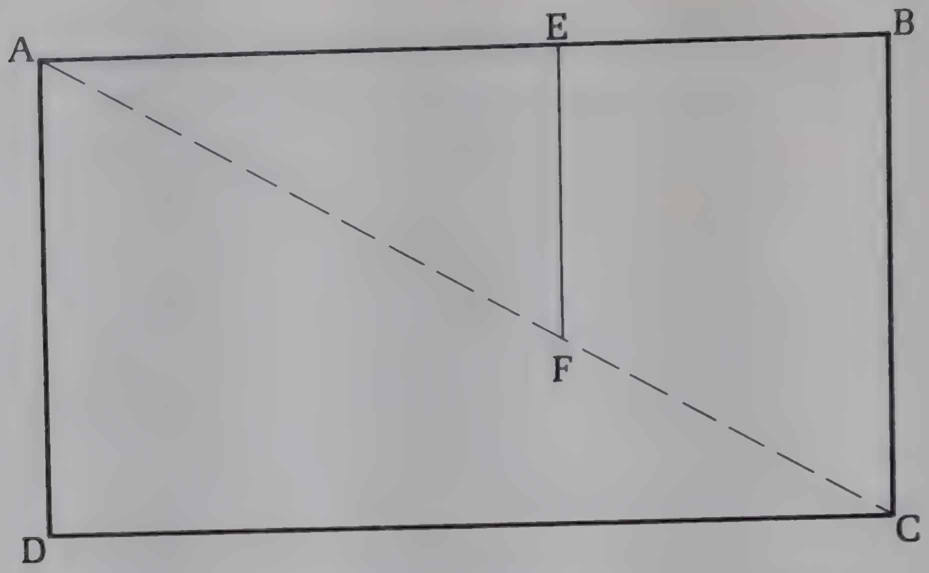


Fig. 5. Geometrical method for sizing an illustration. On a piece of paper draw a parallelogram, ABCD, *the size of the original illustration. Draw the line* AC. *Measure along the line* AB *the desired width* AE *for the illustration. Draw a line* EF *perpendicular to* AB. *The line* EF *is equal to the vertical dimension of the illustration.*

LETTERING ILLUSTRATIONS

On many figures other than maps, letters and numerals of a single size are used throughout. The lettering should be of such size that the height of the characters, after reduction, will be about 2.5–3.0 mm on photographs and at least 1.5–1.75 mm on line drawings, Fig. 4. The proper height for the characters on an original figure can be calculated with an engraver's reduction wheel, a slide rule, or an equation similar to the following, in which x is the height (in millimeters) the characters should be made on the original figure, and 1.5 or 1.75 mm is the height of the characters after they have been reduced and as they will appear on the printed page.

$$x = \frac{\text{Width of original figure} \times \text{Height of reduced characters}}{\text{Width of reduced figure}}$$

For lettering, as well as for drawing the lines and symbols on graphs, use a jet black (India) ink or a strong red ink.

Letters and numerals must be open; they should be drawn with lines of medium thickness. Do not attempt to hand-letter line drawings and photographs unless your work is of professional quality.

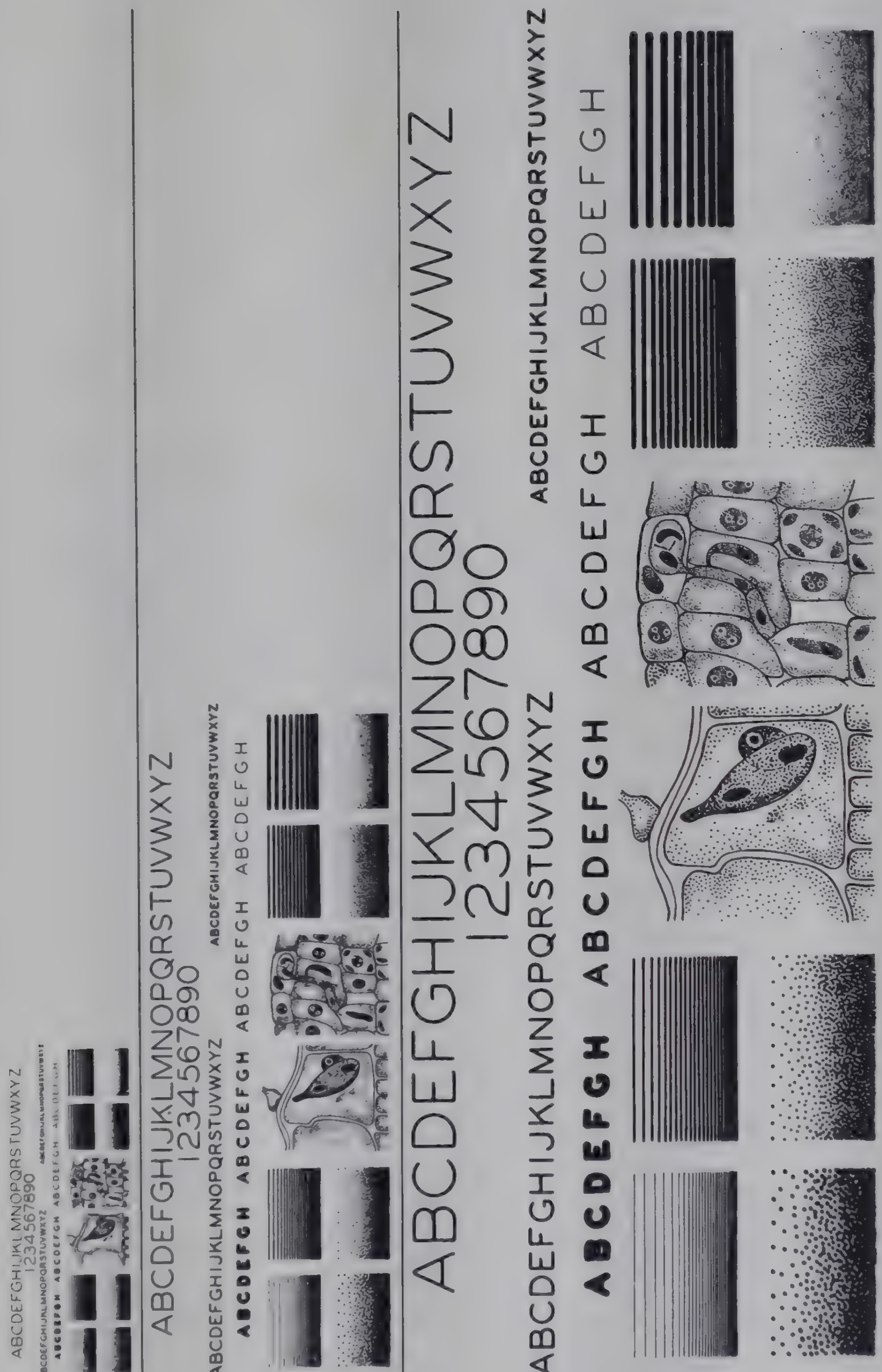

ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZ
ABCDEFGH ABCDEFGH ABCDEFGH
ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZ
ABCDEFGHIJKLMNOPQRSTUVWXYZ
ABCDEFGH ABCDEFGH ABCDEFGH ABCDEFGH
ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890
ABCDEFGHIJKLMNOPQRSTUVWXYZ
ABCDEFGHIJKLMNOPQRSTUVWXYZ
ABCDEFGH ABCDEFGH ABCDEFGH ABCDEFGH

Fig. 6. Letters, numerals, lines, and dots in relation to reduction for the printed page.

Lettering sets and preprinted letters available in art stores are likely to give better results than hand lettering. One of the popular lettering sets consists of templates with characters of various sizes, a special lettering guide, and pens. If letters, numerals, and symbols from dry-transfer or pressure-sensitive sets are used, they should be affixed so securely that they will not be rubbed off. They should not be applied to an illustration that is later to be dry-mounted; heat will remove them.

For a photograph with a very dark background, a white opaque water color can be used to make the letters or to highlight black letters; or a label with black letters on white paper can be affixed to the photograph at an appropriate place.

MARKING ILLUSTRATIONS

On the reverse side of each illustration write the figure number, your name, the word *top* to indicate how the figure should be viewed, and the width you want the figure to be in the journal. You may write the desired width in centimeters, picas, or inches, or you may specify that the figure should be one column or two columns wide or full page width.

For marking a photograph, use a soft pencil or felt-tipped pen (never a ball-point pen) and write very lightly on the back; the photograph should rest on a hard surface so that pressure of the pencil or pen will not dent the surface of the print. Do not use a paper clip on a photograph; it might leave an impression that would show in the reproduction.

If you wish to write a note about a photograph, type it on a separate sheet of paper. Affix the paper to the back of the print, preferably along one edge, with rubber cement or adhesive tape; paste or glue might wrinkle the print.

If information on magnification in a photograph or a drawing is important (it is essential in an electron micrograph or a photomicrograph), give the degree of magnification in a form acceptable to the editor of your journal. The simplest and best way to supply this information for most illustrations is to draw a scale line or bar directly on the print or drawing. As an illustration is reproduced, the line will get the same reduction as the rest of the copy.

An entomologist making a diagnostic drawing of an insect magnified five times may draw a line 5 mm long and label it 1 mm. When the drawing is reproduced, the line will represent 1 mm of insect, regardless of the reduction, and no mention of magnification needs to be made in the legend. The scale line on a micrograph will, of course, represent a much smaller unit of measurement.

Many editors allow authors to designate magnification by a times sign either before or after a number: × 175,000; 16 ×.

Examine several issues of your journal to determine what method or methods of indicating magnification are acceptable to the editor. Whatever method you adopt, you will be responsible for verifying the magnification when you see the proof.

CHECKING FIGURE NUMBERS AND CITATIONS

Check the copy from which your final draft is to be typed to make sure that your illustrations or figures are numbered consecutively as you want them to appear in your article, that each figure is cited at least once in the text, and that each citation refers to the appropriate figure.

LEGENDS

The legends (titles, cutlines) for your figures should be assembled and typed (double-spaced) on a sheet or sheets of paper separate from the text.

Just before the final typing, read each legend in relation to the figure it identifies and then in relation to other legends. Every legend should be clear and concise, and it should be informative enough to identify the figure without reference to the text. It may also be briefly interpretive, pointing out salient features in the figure or calling attention to differences between it and similar figures. Legends for a series of similar figures should be uniform in sentence structure.

A style of legend common in biological journals consists of the abbreviation Fig. followed by the figure number, a period, a title or an elliptical sentence, and possibly one or more complete sentences:

Fig. 2. Bluegill-crappie hybrid taken from Lake Decatur. This

hybrid can be most readily distinguished from the bluegill-warmouth hybrid (Fig. 1) by the shape of the dorsal fin.

LIST OF REFERENCES

See also pages 4, 9, and 133

The heading for the bibliographic list at the end of each article in a journal may be one of these three: Literature Cited (most common), References Cited, or References. The reference works that may be included in a list are determined by the heading.

Literature Cited includes only works that have been referred to or cited in the article and that have been published, scheduled for publication, or deposited in libraries as theses or dissertations.

References Cited may include unpublished as well as published material that has been referred to in the article.

References may include any pertinent material, published or unpublished, cited or uncited in the article.

If you have systematically and accurately recorded your bibliographic data on cards, with the data for each article or book on a separate card, the list of references can be typed from the cards. The semifinal or final draft should be checked against the original references.

The style for a bibliographic list depends on the system of citation in the article. Most biological journals use the name-and-year (or author-date) rather than the number system. Each system has its advocates. The name-and-year system, which has been growing in popularity among scientific journals, permits the addition or deletion of entries with little disturbance to the text or the bibliography. Its advocates claim it is less subject to error when entries are added or deleted. In addition, they point out that it enables a reader to make an immediate association of a cited fact or idea with its authority and time. Advocates of the number system claim that it is less disturbing to the average reader and that it presents fewer editorial problems in citing articles with complicated authorship.

STYLE FOR NAME-AND-YEAR SYSTEM

See also pages 9 and 162

For a journal that employs the name-and-year system of citation, list entries in the bibliographic section alphabetically.

In this system the main parts of a complete entry for an article in a periodical are (i) name(s) of author(s), (ii) year of publication, (iii) title of article, (iv) name of journal, with volume number, issue number, and inclusive pages of the article.

The main parts of a complete entry for a book are (i) name(s) of author(s), (ii) year of publication, (iii) title of book, (iv) name and city of publisher, (v) number of pages in book.

Not all journals include all the items; for example, most of them omit the issue number of a periodical and the number of pages in a book.

The two entries below, one for a journal article and one for a book, illustrate the basic style for the name-and-year system. Each main part is closed with a period.

Schneider, Michael J., Robert F. Troxler, and Paul D. Voth. 1967. Occurrence of indoleacetic acid in the bryophytes. Bot. Gaz. 128(3):174–179.

Davis, Nuel Pharr. 1968. Lawrence and Oppenheimer. Simon and Schuster, New York. 384 pp.

Details of the style, as well as some of the deviations from it, are discussed in succeeding pages of this chapter. A few journals place the year of publication at the end of the entry and thereby needlessly inconvenience the reader. In research moving as fast as that in biology, the date is so important that the appropriate position for it is close to the name(s) of the author(s), both in the text citation and in the list of references.

STYLE FOR NUMBER SYSTEM

See also page 10

For a journal that employs the number system, list references in the order in which they are cited in the article or book, unless the journal consistently follows another practice. Number (or renumber) entries after all additions and deletions have been made; carefully check citation numbers in the text against the final reference numbers.

An entry for the number system is similar to that for the name-and-year system except that it is preceded by a numeral on the line (not a superscript as in the text citation) and a period:

38. Nanny, D. L. 1966. Corticotype transmission in *Tetrahymena*. Genetics 54:955–968.

Most journals following this system arrange entries in the order of citation in the article, book, or chapter of book for which the bibliography is intended; only a few arrange them alphabetically. Some set each entry paragraph style, some use hanging indention (first line flush left, the following line or lines indented), and some run all lines flush left.

NAME(S) OF AUTHOR(S)

See also pages 9 and 162

In listing authors' names in bibliographies, most journals substitute initials for given names. A few list the names as supplied by authors for their by-lines.

As the number of biologists has proliferated, the practice of substituting initials for given names has led to some confusion through misidentification of authors having the same initials and family names. In preparing a bibliographic list for a journal that customarily substitutes initials for given names, spell out at least one given name of any author who you believe might be mistaken for another if only initials were used. Inform the editor of your reason for doing so.

Most biological journals reverse the normal order of the family and given name(s) or initial(s) of the sole author or the first of the joint authors listed for an article or book. *John C. Smith* as the sole or senior author would become *Smith, John C.*, or *Smith, J. C.*, in a bibliographic list; *F. W. Day, Jr.*, would become *Day, F. W., Jr; C. G. Child, III*, would become *Child, C. G., III*. A few journals interchange the family and given name(s) or initial(s) of all authors listed in the entry for an article or book of multiple authorship.

Compound family names of foreign origin that have been Americanized are usually treated in the same manner as other Americanized names. Consideration is given to an author's preference in the spelling of his family name. *American Men of Science* (1965–1967) recognizes such preferences. A few examples are given below:

Name as in By-Line	*Name as in Bibliography*
Joseph P. Della-Corte	Della-Corte, J. P.
E. C. Bate-Smith	Bate-Smith, E. C.
James M. van der Veen	van der Veen, J. M.
John Edward Vanderveen	Vanderveen, J. E.
Richard C. De Long	De Long, R. C.
D. M. DeLong	DeLong, D. M.
A. J. de Lorenzo	de Lorenzo, A. J.
William F. DeLorenzo	DeLorenzo, W. F.

In many countries—Canada, Czechoslovakia, Denmark, England, Finland, Italy, Norway, Poland, Sweden, and the USSR, for example—given and family names follow the order used in the United States, and most of them are similarly transposed for alphabetical listing.

Some Spanish names and names of Spanish origin include the maternal after the paternal family name. In an alphabetized list, the paternal name precedes the maternal name:

Casimir Gómez Ortega	Gómez-Ortega, C.
Juan Pérez y Fernández	Pérez y Fernández, J.

The Spanish word *hijo* (*h.*) means *son;* it is equivalent to *junior* and should be so translated. *Gonzalo Ley* (*hijo*) becomes *Ley, Gonzalo, Jr.,* or *Ley, G., Jr.,* in a bibliographic list published in the United States.

In a transposed Brazilian or Portuguese name the particle (do, da, dos, das) follows the given name(s) or initial(s):

Silvio do Amaral	Amaral, Silvio do
A. C. dos Santos	Santos, A. C. dos

In a transposed compound French name, the definite article (le, la, les) alone or in combination with the preposition de (du, de la, des) precedes the family name; de (or d') alone may follow the given name(s) or initial(s):

J. LeBeau	LeBeau, J.
R. L'Epée	L'Epée, R.
V. du Bary	Du Bary, V.
A. de Bary	Bary, A. de
B. d'Aubiac	Aubiac, B. d'

In a transposed Dutch name, the particle or particle phrase sometimes follows the given name(s) or initial(s) and sometimes precedes the family name:

L. A. de Vries	Vries, L. A. de
Hugo de Vries	de Vries, H.
L. W. van Horts van Bing	Horts van Bing, L. W. van
Adriaan D. de Groot	de Groot, A. D.
Sybren R. De Groot	De Groot, S. R.

In an alphabetical list of names, *de Groot* might be alphabetized under *G* and *De Groot* alphabetized under *D*.

A particle (im, von, zu, zum, zur) or its abbreviation in a German name usually follows the given name(s) or initial(s) and should be spelled out:

C. von Holt	Holt, C. von
H. zur Horst-Meyer	Horst-Meyer, H. zur
Ludwig v. Obersteg	Obersteg, L. von

In Hungarian the family name regularly precedes the given name, and transposition is unnecessary.

Farkas Karoly	Farkas, K.
Szent-Györgyi Albert	Szent-Györgyi, A.

An Egyptian or other Arabic family name follows the given name(s), as in the United States:

Hassan Fahmy Khalil	Khalil, H. F.
Mohamed Metwali Naguib	Naguib, M. M.

When a prefix or its variant (el, ibn, abdel, abd-el, abdoul, abu, abou, aboul) or the particle *el* alone precedes a name, it is hyphenated to the name it precedes:

Aly Abdel Aziz	Abdel-Aziz, A.
Youssef Abou-el-Ezz	Abou-el-Ezz, Y.
Aziz Ibn Saud	Ibn-Saud, A.
Kamel el Metwali	el-Metwali, K.
Hedieh Khalil el Agouz	el-Agouz, H. K.

In Chinese publications the family name precedes the given name (usually hyphenated):

Chen Tai-chien	Chen, Tai-Chien
Lin Ke-sheng	Lin, Ke-Sheng

But in American and British journals a Chinese name is usually anglicized and transposed:

C. Ying Chang	Chang, C. Y.
Hsi Fan Fu	Fu, H. F.

If *Sen* or *Das* precedes an Indian name, it is included with the family name:

B. C. Sen Gupta	Sen Gupta, B. C.
K. P. Das Gupta	Das Gupta, K. P.

All elements of Vietnamese and Thai names are taken in the order in which they appear in the by-line and are joined by hyphens; lowercase is used for the second element:

Nguyen Lâm Tiêp	Nguyen-lâm-Tiêp

Many reports issued by committees, government agencies, or other organizations do not reveal the identity of the authors and do not name any individuals as chiefly responsible for the publications. In the bibliographic entry for such a report, the organization may be named as the "author." If an editor or chairman is named as chiefly responsible, he may be listed as "author"; his name should be followed by a comma and *editor* or *chairman*. An anonymous article or editorial in a periodical or newspaper may be listed under *Anonymous* (abbreviated to *Anon.* in the text citation).

Some books with no authors named are better known by their titles than by the names of their editors or publishers. A book of this type may be listed under its title:

Webster's Third New International Dictionary of the English Language, Unabridged. 1961. G. & C. Merriam Company, Springfield, Massachusetts. 2662 pp.

In the text citation, the title may be shortened; for example, the dictionary named above may be referred to as *Webster's Third New International Dictionary* (1961) or, after the first mention, as *Webster's Third* (1961).

YEAR OF PUBLICATION

For the publication date of an article, use the year shown in the journal unless you know that the actual year of issue was later than the year shown and the time of publication is important to your citation.

For the publication date of a book, use the year on the title page or, if no date is shown there, the latest copyright date on the reverse side of the title page. If no date is given in either place and you have determined it from library records or other reliable sources, supply it enclosed in brackets. If you are unable to determine the exact year of publication, supply an approximate date followed by a question mark; enclose date and question mark in brackets.

For a book that has been reprinted or has had more than one edition, use as the year of publication the date of the reprinting or edition you cite (determined usually by latest copyright date). You may add in brackets at the end of the entry an appropriate notation, as

[First published in 1859.]

To show the chronology of publication, some authors using the name-and-year system advocate including in the text citation the date of first publication, as well as the date of the edition or printing cited. If you believe that both dates will be helpful to the reader, include them as in the following example:

Darwin [1859] 1959:346

This citation will indicate to the reader that the passage referred to can be found on page 346 of the 1959 reprinting of a work first published in 1859.

In a bibliography arranged alphabetically, if two or more cited articles or books by the same author or authors (names in the same order) have the same publication year, list the entries chronologically, with lowercase italic letters (*a, b, c*) after the dates:

Smith, R. P., C. R. Jones, and L. B. Hicks. 1969*a*.
Smith, R. P., C. R. Jones, and L. B. Hicks. 1969*b*.

Include in each entry the name(s) of the author(s). Leave to the editor the option of substituting a 3-em dash for a repeated name or for names repeated in the same order. The dash is used even when the publication years are not the same:

Smith, R. P., C. R. Jones, and L. B. Hicks. 1969*a*.
———. 1969*b*.
———. 1970.

TITLE OF ARTICLE OR BOOK

In listing the title of an article or book for your bibliographic section, copy the wording, spelling, and, with some exceptions, the punctuation of the title as it appears on the first page of the article or on the title page of the book.

Follow the style of capitalization in the bibliographic section of the journal for which you are writing. Most biological journals capitalize only the first word and proper nouns and adjectives in the titles of both articles and books. Some follow the "down" style for journal articles but capitalize "important" words in the titles of books. Some italicize the titles of books. See examples below for type style of book titles.

If the title you are copying is set in capital letters, you may need to refer to the text to determine whether certain words are regarded by the author as proper nouns or proper adjectives. Observe the conventions of capitalization of titles in German, French, and other foreign languages.

A book title that depends for understanding upon differences in type size or arrangement of type on the title page may need additional punctuation, usually a colon.

THE DREAMS OF REASON
Science and Utopias

In listing the title above, or one like it, punctuate it as follows and write it in the style adopted by your journal:

The dreams of reason: science and utopias

The Dreams of Reason: Science and Utopias

The Dreams of Reason: Science and Utopias

NAME OF PERIODICAL

Most scientific journals abbreviate the names of cited periodicals in accordance with recommendations of Subcommittee Z39.5 of the American National Standards Institute (formerly United States of America Standards Institute):

J. Anat. (Journal of Anatomy)

Proc. U.S. Nat. Mus. (Proceedings of the United States National Museum)

Ann. Mo. Bot. Gard. (Annals of the Missouri Botanical Garden)

For the recommendations, see *American National Standard for the Abbreviation of Titles of Periodicals,* a 1969 publication prepared by Subcommittee Z39.5 of ANSI. For a list of abbreviated journal names, refer to *ACCESS* (1969); *Biological*

Abstracts List of Serials with Title Abbreviations (published each January); or (for a clinical journal in medicine) a January issue of *Index Medicus.*

Spell out every word in a journal title for which you cannot find an abbreviation. Do not abbreviate a title consisting of one word, as *Phytopathology.*

A style referred to hereafter as the library style has been adopted by a few journals for listing the titles of periodicals. It is based on rules outlined in the front matter of Volume 1 of the *Union List of Serials in Libraries of the United States and Canada* (Titus 1965). Explained in detail by Trelease (1969: 100–103), the library style simplifies reference work for many researchers by presenting the abbreviated titles in the word order in which the full titles are listed in the card catalogs of practically all libraries. A periodical title that includes both the name of the sponsoring organization and *Journal, Proceedings, Annals,* or similar word is filed under the name of the organization. In a card catalog, *Annals of the Entomological Society of America* is not filed under *Annals* but under the name of the society.

Below are the titles of three periodicals as they would be listed in a bibliography following the library style:

Entomol. Soc. Amer., Ann. (sponsoring organization named)
J. Lipid Res. (no sponsoring organization named)
Mass. Audubon Soc., Bull. (sponsoring organization named)

A few scientific journals spell all words in the titles of periodicals because their editors or editorial boards believe that the cost of checking abbreviations in the editorial department is greater than the printing costs that might be saved by abbreviating.

VOLUME, ISSUE, AND PAGES OF PERIODICAL

Use arabic numerals for the volume number of a periodical even though the original volume numbers are roman numerals. If you include a number to represent a volume subdivision (issue, number, supplement), place it after the volume number and enclose it in parentheses. Most journals omit this number except when the subdivision is paged independently:

2(4):47–56 54 (suppl. 2):1–12

In listing an article in a special series, precede the volume number with the number or letter designating the series:

Ser. 3, 2:120–136 II, 2(4):1–56 Ser. C, 2:12–16

VOLUME AND PAGES OF BOOK

In an entry for a book title that covers more than one volume, include only the volume or volumes containing the material you cite in the text.

Some journals include in each entry for a book the total number of pages. Many do not. If the journal for which you are writing includes the number of pages, for any reference containing important prefatory and appended pages with lowercase roman numerals, list the total number of pages:

viii + 996 + xx pp.

ILLUSTRATIONS

Mention in the bibliographic section only illustrations that are separately paged and of particular importance.

MISSING BIBLIOGRAPHIC DETAILS

If for the sake of clarity you add a bibliographic detail (such as author, date, or publisher) that is missing from the publication itself, enclose it in brackets.

EXAMPLES OF BIBLIOGRAPHIC ENTRIES

Various types of authorship, publication, and publisher that you may encounter in making up a bibliographic section are given below in boldface type. Examples of article or book entries are given in lightface type.

Author, given name as in by-line. Abstract only.

Hildebrandt, Albert C. 1948. Influence of some carbon compounds on growth of plant tissue cultures in vitro. Anat. Rec. 100:674. (Abstr.)

Author, prefix in name of foreign origin anglicized. Given name (William) on title page abbreviated to initial. Miscellaneous numbered publication of federal agency.

Van Dersal, W. R. 1938. Native woody plants of the United States, their erosion-control and wildlife values. U. S. Dep. Agr. Misc. Publ. 303. 362 pp.

Author, prefix in French name not anglicized. Pages in volume separated.

Bary, A. de. 1886. Ueber einige Sclerotinien und Sclerotienkrankheiten. Bot. Zeit. 44:377–387, 393–404, 409–426, 433–441, 449–461, 465–474.

Author, hyphenated name. Book with subtitle. Number of pages given.

Gwynne-Vaughan, H. 1922. Fungi: Ascomycetes, Ustilaginales, Uredinales. Cambridge University Press, London. 232 pp.

Author, name transliterated. Title of article in both English and foreign language. Main text in foreign language. Summary in English. Each number or issue of periodical paged separately.

Nishikado, Y. 1921. On a disease of the grape cluster caused by *Physalospora baccae* Cavara [in Japanese, English summary]. Ann. Phytopathol. Soc. Jap. 1(4):20–42.

Authors, names transliterated. Periodical without volume numbers, each issue numbered independently. Text in foreign language.

Gavrilov, K. A., and T. S. Perel. 1958. Earthworms and other invertebrates in the soil under forests in Vologda region [in Russian]. Pochvovedenie 1958(8):133–140.

Authors, two or more. Numbered report of institution. Joint sponsorship of publication indicated.

Gloyna, E. F., E. R. Hermann, and W. R. Dryman. 1955. Oxidation ponds—waste treatment studies, radioisotope uptake, and algae concentration. Univ. Texas, Dep. Civil Eng. Tech. Rep. 2. (Also AECU-3113.)

Bulletin, separate publication with author named. Name of author as in by-line.

Bryant, Margaret S. 1951. Bibliographic style. U. S. Dep. Agr. Bibliogr. Bull. 16. 30 pp.

Book, number of pages given.

Schwarts, R. J. 1955. The complete dictionary of abbreviations. Thomas Y. Crowell Co., New York. 211 pp.

Book, part of.

Overstreet, H. A. 1925. The psychology of effective writing. Pages 87–109 *in* H. A. Overstreet, Influencing human behavior. W. W. Norton & Co., New York.

Book, author not named, better known by title than by publisher or editor.

American Men of Science. 1965–1967. The physical and biological sciences, 11th ed. Edited by Jaques Cattell Press. R. R. Bowker Company, New York. 6 vols.

Chapter or paper in book by several authors. Editors of book named.

Link, G. K. K. 1928. Bacteria in relation to plant diseases. Pages 590–606 *in* E. O. Jordan and I. S. Falk, eds. The newer knowledge of bacteriology and immunology. University of Chicago Press, Chicago, Ill.

Chairman of committee, listed as author. Society sponsoring periodical not in title but considered necessary for identification.

Riker, A. J., chairman. 1952. Literature citations: how biologists like them. AIBS [Amer. Inst. Biol. Sci.] Bull. 2(1):18–19.

Committee of society, listed as author. One-word name of journal not abbreviated.

American Phytopathological Society, Committee on Standardization of Fungicidal Tests. 1943. Definitions of fungicide terms. Phytopathology 33:624–626.

Editor of book—no author(s) named.

Hamer, P. M., ed. 1961. A guide to archives and manuscripts in the United States. Yale University Press, New Haven, Conn. 775 pp.

Federal agency, listed as author. Two or more volumes.

U.S. Bureau of the Census. 1927. United States census of agriculture 1925. U.S. Government Printing Office, Washington, D.C. 3 vols.

Federal agency, listed as author. Pages of publication not numbered.

U.S. Department of Agriculture, Plant Pest Control Division, Pesticide Regulation Section. 1957. A summary of certain pesticide chemical uses. Loose-leaf pub. n.p.

Federal agency, listed as author, omitted as publisher. Revised edition.

U.S. Government Printing Office. 1967. Style manual. Revised ed. Washington, D.C. 512 pp.

Federal agencies, publication of one distributed by another. Part of series. Two authors.

Finston, H. L., and M. T. Kinsley. 1961. The radiochemistry of cesium. Nat. Acad. Sci., Nuclear Sci. Ser. NAS-NS-3035. Office of Technical Services, Dep. of Commerce, Washington, D.C.

Illustrations, important and not included in pagination of text.

Smith, E. F. 1917. Mechanism of tumor growth in crowngall. J. Agr. Res. 8:165–183; figs. 4–65.

Newspaper article. Pages separated. Name of author as in by-line.

Maverick, Maury. 1944. The case against "gobbledygook." New York Times Magazine, 21 May:11, 35–36.

Patent, original not seen.

Penn, F. H. 1942. Hydrogenated butter method. U.S. Pat. 2,272,578 Feb. 10 Abstr. in Offic. Gaz. U.S. Patent Office 535:322.

Publication of a society (*Annals, Bulletin, Journal, Memoirs, Papers, Proceedings, Transactions*, followed by name of society); style for a periodical following recommendations of Subcommittee Z39.5 of ANSI and using abbreviations in *ACCESS, Biological Abstracts List of Serials with Title Abbreviations*, or *Index Medicus:*

Buck, D. H., C. F. Thoits, III, and C. R. Rose. 1970. Variations in carp production in replicate ponds. Trans. Amer. Fish. Soc. 99(1):72–79.

Publication of a society, as above; style for a periodical following library system—see page 160.

Cresson, E. T., Jr. 1947. A systematic annotated arrangement of the genera and species of the Neotropical Ephydridae (Diptera). Amer. Entomol. Soc., Trans. 73:35–61.

Progress report, part of annual report of government agency.

Auerbach, S. I., and R. M. Anderson. 1959. Ecological research. Pages 18–54 *in* Physics Division annual progress report for period ending 31 July 1959. ORNL-2806. (Oak Ridge National Laboratory, Oak Ridge, Tenn.)

Report in annual report of research company. Two or more authors.

McClellan, R. O., J. R. McKenny, and L. K. Bustad. 1961. Metabolism and dosimetry of cesium-137 in rems. Pages 55–59 *in* Hanford biology research annual report for 1960. HW-69500. (Hanford Laboratories, Richland, Wash.)

Series in publications of a society. Title of periodical not altered as in library system.

Salaman, R. N., and F. C. Bawden. 1932. An analysis of some necrotic virus diseases of the potato. Proc. Roy. Soc. London, Ser. B, 111:53–73.

Service agency listed as author. Book.

Chemical Abstracts Service. 1961. Chemical Abstracts list of periodicals with key to library files. American Chemical Society, Washington, D.C. 397 pp.

State agency, listed as author. Report for fiscal year issued as bulletin.

Wisconsin Agricultural Experiment Station. 1950. What's new in farm science; 66th annual report 1948/49. Part I. Wisconsin Agr. Exp. Sta. Bull. 491. 88 pp.

Thesis on microfilm. Name of author as in by-line.

Rafferty, Nancy S. 1958. A study of the relationship between the pronephros and the haploid syndrome in frog larvae. Ph.D. Thesis. University of Illinois (Libr. Congr. Card No. Mic. 58-5479). 41 pp. University Microfilms, Ann Arbor, Mich. (Diss. Abstr. 19:1146.)

Translation. Publication of federal agency.

Barbashova, Z. I. 1966. Adaptive changes in oxygen transport in the blood, cellular plasma, and mitochondria. (Transl. from Russian.) NASA TT F-420:16–18.

Two or more independent articles in same year by same author, or by same authors with names in same order (in typewritten copy, names of authors should be repeated; a 3-em dash is usually substituted for the names in the second and following entries when copy is set in type)—see page 158.

Magoon, M. L., R. W. Hougas, and D. C. Cooper. 1958*a*. Cytogenetic studies of tetraploid hybrids in *Solanum* for hexaploid-diploid matings. J. Hered. 49:171–178.

Magoon, M. L., R. W. Hougas, and D. C. Cooper. 1958*b*. Cytogenetic studies of complex hybrids in *Solanum*. J. Hered. 49:285–293.

6. The Final Draft

INTRODUCTION

When you give your manuscript to a typist for preparing the final draft, explain the differences, however trivial, between office practice and the style of the journal for which the copy is being typed. Time spent on these details may speed publication of your paper after its acceptance. The final draft should follow the journal style exactly—to the extent you are able to ascertain it. Many of the suggestions in this chapter are addressed to the person who will type your manuscript.

PAPER

Use a white bond paper of good quality, 20- or 16-pound weight and 8½ by 11 inches (about 22 by 28 cm), for the ribbon copy of the typescript. Do not use so-called erasable paper or paper with a glazed or rough surface that will not take ink or erasures. If carbon copies are made, they may be on lighter weight bond, or other thin paper of good quality, but not on onionskin.

TYPING

Use a typewriter with standard characters, which are more easily read than caps and small caps or characters that imitate hand-writing. Keep the faces of typewriter keys clean with a brush or typewriter cleaning fluid. Use a ribbon that makes a clear black imprint. If the ribbon is heavily inked, regulate typing pressure on the machine to prevent smearing. Replenish carbon paper often enough to ensure legible copies—usually after making five or six copies.

Number pages consecutively, each in the upper right-hand corner.

Type on one side of the paper only, keep lines approximately uniform in length, and leave margins of 2.5 to 4 cm (1 to 1½ inches) at top, bottom, and sides for editors' markings and queries. Avoid dividing a word at the end of a line. Do not type the title and subheads entirely in capital letters. If you capitalize only the words you would capitalize in text, a copy editor can easily mark your title and heads to make them conform to the journal style.

Double-space the text, quotations, footnotes, tables and their headings, legends, and references. Use even greater spacing above and below equations and formulas. *Do not single-space any part of the typescript.*

If the manuscript is long, start a new page for each main section. Arrange copy in the following order: (i) title, running head, by-line, name and address for mailing; (ii) abstract and key words; (iii) text; (iv) acknowledgments; (v) list of references; (vi) footnotes to text; (vii) tables; (viii) legends for figures; and (ix) figures.

Make at least two carbon copies or xerographic copies identical with the typescript in paging and in all insertions and corrections. All copies should be on good quality white paper; the characters must be clear and black. If you submit at least one carbon or xerographic copy with the transcript, you may expedite editorial review. Keep one copy for reference and for insurance against loss in the mail.

READING COPY

After the final typing, which should be read first by the typist, check the entire manuscript at least twice for typographic errors, paying particular attention to quotations, citations, technical terms, names of persons and places, and numerical data. One of these checks should be made with another person reading aloud the pages from which the final draft was typed.

Check against the source any bibliographic reference that in the previous draft was not compared with the original.

MAKING CORRECTIONS AND INSERTIONS

Type brief corrections and insertions, or print them legibly, above the lines concerned. Show by a caret (∧) the exact place for each insertion. Do not make corrections or insertions in margins or on slips of paper (flyers) attached to the pages. Retype any page needing one or more lengthy insertions. If the retyping results in a page only partly filled, draw a diagonal line below the text to indicate that additional material follows on another page.

If you insert a page between pages that have been numbered, give the new page a number and letter appropriate to its position. Then, on the page preceding and on the page following, indicate that the page has been inserted. Follow a similar procedure if you insert more than one page. If, for example, you insert two pages between pages 3 and 4, number the new pages 3A and 3B. At the bottom of page 3 write "Pages 3A and 3B follow." At the top of 3A write "Page 3B follows." At both top and bottom of 3B write "Page 4 follows." At the top of page 4 write "Pages 3A and 3B precede."

Do not staple or bind the typescript.

INDICATING POSITIONS FOR FIGURES AND TABLES

To guide the editor and printer in making up pages, indicate by a circled marginal note on the final draft of your typescript a desirable location for each figure and table (see note in left

Fig 7 here

margin). Whether a figure or table can be placed where you want it depends mainly upon the space occupied by your figures and tables in relation to the amount of text.

FINAL CHECKLIST

Before you decide that your manuscript is ready to be mailed to the journal editor, check to see that you have completed the operations represented by the following list of items. If you reproduce this list by xerography or a similar process, you can use it to check off each item as you make a final review of your typescript.

1. Numbered the text pages of your final draft consecutively, beginning with the first or title page.
2. Numbered your tables (not more than one on a page) consecutively in the order in which you want them presented in the journal.
3. Read the title and headings of each table objectively to determine whether the table can be understood without reference to the text.
4. Searched your final draft for references to tables to make certain that each table is referred to and that each of the references is to the appropriate table.
5. Indicated by a marginal note a place for each table.
6. Examined your text, tables, and legends to make certain that each reference cited is accurately represented in the bibliographic section.
7. Examined your bibliographic section to make certain that each work listed there is accurately referred to in the text, tables, or legends.
8. Examined each item in the bibliographic section for accuracy of date, wording, spelling, and other details (comparison made with original article or book, or with previous draft that has been carefully checked with original source—not with your rough notes, with reprints, or with citations by other authors).

9. Prepared adequate legends for all figures (legends double-spaced on a separate page or pages).
10. Made certain that figures are numbered consecutively in the order in which you want them to appear in your article, that each figure is referred to at least once in the text, and that each reference in the text is to the appropriate figure.
11. Indicated by a marginal note a place for each figure.
12. Examined the text for references to footnotes, making sure that each such reference has a footnote and that each footnote is referred to in the text.
13. Reconsidered the appropriateness of your title and index words.
14. Reviewed the special requirements of the journal to which you have elected to submit your manuscript and made certain that you have met them.
15. Carefully read your final draft at least twice, once against the pages from which it was typed.
16. Prepared as many copies of your text, tables, and illustrations as are required by the editor to whom you are submitting your manuscript and by the institution for which you work.
17. Retained for your file a complete copy of your manuscript and accompanying material (corrections and insertions included).
18. Included copies of releases for material requiring releases.
19. Included on the first page of the typescript the address to which letters and proof should be sent.

SUBMITTING THE MANUSCRIPT

In submitting your manuscript, enclose with it a short covering letter in which you give the editor any information you think he might find helpful, for example, the number of pages of text, the number of tables, and the number of figures you are submitting; the number of copies of text, tables, and figures; whether the figures are with your letter and manuscript or are being sent separately; whether your manuscript is a single article or part of a series; whether it has been presented at a scientific meeting and, if so, where and when. Give the address to which correspondence and galley proof should be mailed.

If the journal carries articles of more than one category, specify the one in which you believe your article belongs: (i) a scientific paper based on original research, (ii) a subject review article, or (iii) a combination of the two; (iv) a definitive paper; (v) a provisional communication or preliminary note.

If your field of research is highly restricted, you might suggest the names of several persons you consider qualified as referees for your manuscript.

If you have an unusually large number of tables or figures, tell the editor whether you are willing to have some of them held out of the article and sent to a repository such as the two following: (i) The National Auxiliary Publications Service of the American Society for Information Science (formerly American Documentation Institute), care of CCM Information Corporation, 909 Third Avenue, New York, New York 10022; (ii) the Center for Research Libraries (formerly Midwest Inter-Library Center), 5721 South Cottage Grove Avenue, Chicago, Illinois 60637.

The editor can arrange for deposit of your excess material and announce with your article where it will be available for study.

Do not submit a manuscript for simultaneous consideration by two or more journals, or submit for publication a paper that has been published or accepted for publication, unless you have the specific written permission of all editors concerned.

Do not fold your manuscript. Mail it flat, by first class surface mail or air mail, in a sturdy manila envelope or in the package with the illustrations.

Mail photographs and drawings flat, unfolded, or, if they are large and can be rolled without being damaged, in a sturdy mailing tube. If you send them flat, place them in a commercial mailer, or between sheets of strong, preferably corrugated, cardboard with an outer wrapping or envelope of durable paper.

7. Review of Manuscripts

INTRODUCTION

Editors of most biological journals will not accept a manuscript for publication without the advice of reviewers or referees, scientists well qualified to judge manuscripts in their fields. The identity of referees may or may not be revealed to the authors whose papers they review.

Referees are valuable adjuncts to editorial boards in helping to maintain high standards of publication. They can, for example, recommend the rejection of articles that appear to them clearly unacceptable. In the articles they recommend for acceptance, they can point out errors in fact or interpretation, call attention to inaccurate or ambiguous statements, advise condensing or enlarging specific sections, and offer suggestions for strengthening the presentation of material and clarifying the writing.

An author should assume that a referee's criticisms and comments are made in a helpful spirit, and he should consider them objectively. A referee's misunderstanding of passages in a manuscript may arise from lack of clarity in the writing. If an author rejects an important suggestion by a reviewer, he should tell the editor why, but he and the editor should not engage in an emotional debate.

Every author should realize that his editor is responsible not only for the form of published papers but also for the selection of papers appropriate to the readership and for the maintenance of high scientific standards. Although the author is willing to be answerable for the accuracy of information in his paper and for his statements, the editor fails in his duty if he does not challenge statements that appear to him illogical or not borne out by data. Few manuscripts are accepted for publication without some revision.

Rules of good practice for referees are presented below for two reasons: to give authors an appreciation of the difficult work done by referees in making manuscripts ready for publication, and to guide authors who may be asked to review the manuscripts of others.

GOOD PRACTICE FOR REFEREES

Read, evaluate, and return each manuscript to the editor promptly. Advise the editor if you foresee a delay of more than 2 weeks.

Be conscientious in your reading; authors frequently complain that referees do not read their manuscripts carefully.

Be objective in evaluating each manuscript and in writing your comments. Avoid acrimony. Test your critique for fairness and objectivity by asking yourself if you would be willing to sign and send it to the author.

If a manuscript needs changes, be specific in making suggestions. The author of an excessively long manuscript will not be helped by a comment such as "This manuscript is too long. Condense it to half." Give specific directions for eliminating unimportant portions or for condensing expanded writing. Indicate errors in grammar or rhetoric. Call attention to either verbose or cryptic writing.

Do not make corrections and comments directly on the manuscript pages unless the policy of the editor permits this practice.

Do not consider your opinions infallible: you might reject a "breakthrough" manuscript in the belief that it is "crackpot."

On the other hand, do not be misled by persuasive writing that is not based on adequate data and statistically proper controls.

Remember that the contents of each manuscript are the property of the author. Treat the material as confidential. Do not discuss a manuscript with anyone except the editor.

In evaluating the paper, consider its scientific merit, its suitability for readers of the journal, and the quality of presentation.

Send two copies of each critique to the editor. One copy, for the editor, should be signed and dated. The other copy is for the editor to send to the author if he wishes to do so. It should not be signed unless both you and the editor want your identity to be revealed to the author.

CHECKLIST FOR REFEREES

The following checklist should be helpful to referees in reviewing papers and to authors in analyzing their papers.

Item	*Comment*
1. Has material in the manuscript been published previously?	If you know that any of the material in the manuscript has been published by the author or by other researchers, inform the editor of the fact and give details.
2. Do all parts of the manuscript warrant publication?	Some parts of the manuscript may not be worthy of publication. Other parts, such as extensive supplementary tables or long reference lists, may merit publication but be costly to print and of interest to only a few readers. You may suggest to the editor that material of this kind be deposited with the National Auxiliary Publications Service or other repository (see "Submitting the Manuscript," Chapter 6).

Item	*Comment*
3. Is the manuscript more suitable for some other journal?	If you believe it is, explain your reason to the editor and name one or more suitable journals.
4. Is the manuscript in proper form?	If you think the form or organization should be improved, list the changes you suggest, but do not mark the manuscript unless you know that the editor approves this practice.
5. Have any ideas been overemphasized or underemphasized?	List ideas that you think have been either overemphasized or underemphasized, and make suggestions for revision.
6. Should some sections of the manuscript be expanded, condensed, or omitted?	In suggesting changes be specific, but leave the actual revising to the author.
7. Do you find unnecessary repetition or duplication?	A common fault is repetition in the text of data in tables or figures. Suggest that tabular data should be interpreted or summarized, not merely repeated, in the text.
8. Are the author's statements clear?	Challenge statements that to you are ambiguous. Suggest by examples how clarity can be achieved, but do not merely substitute your style for the author's.
9. Can you suggest improvements in the illustrations?	Note particularly whether graphs have any letters, numerals, or symbols that may not be legible when they are reduced and whether photographs have superfluous areas that might be cropped.
10. Are form and arrangement of illustrations and tables satisfactory?	Call attention to graphs that lack readability because they are crowded with too much information or that are wasteful of space because the information on several could be placed on one without loss of read-

Item	*Comment*
	ability. Look for tables that need reorganizing. (Construction of tables is described on pages 136–141 of this manual; graphs are discussed on pages 142–145.)
11. Do you find errors of fact, interpretation, or calculations?	Be alert for errors of fact and interpretation in the text. Scan and spot-check calculations.
12. Are the experimental methods adequately described?	Ask yourself if the experimental procedures have been presented in enough detail to enable a reader to repeat the work reported. (Well-known standard procedures should be named but not described.)
13. Has the author cited the pertinent, and only the pertinent, literature?	If the author has omitted references you believe are important, cite them; if he has included references you regard as inconsequential or not pertinent, suggest deleting them.
14. Have key words been provided by the author? If so, do they represent the paper adequately?	If key words have not been provided, or if they are inadequate, give appropriate examples. (Key words are discussed on page 130.)
15. Is the abstract specific, representative of the paper, and in the correct form?	Be explicit in your evaluation. (The content and form of the abstract are discussed on pages 128–130.)
16. Is the title of the paper appropriate and likely to serve its purpose?	If the title seems to you inadequate or otherwise faulty, point out its shortcomings, but leave the rewording to the author. (The purpose and construction of titles are discussed on pages 126–127.)

8. Manuscript into Type

INTRODUCTION

The final work on the manuscript before it is set in type is done by a copy editor, who may be a member of the journal staff or an employee of the publisher or printer.

The copy editor checks the manuscript for consistency of capitalization, abbreviations, and punctuation and for accuracy of spelling, citations, and references. Also, he calls attention to any faulty statements he notices—ambiguous or inconsistent statements that may have been overlooked by the manuscript editor or other members of the editorial staff. Finally, he marks the manuscript pages for the typesetter in accordance with a set of specifications (discussed below).

An author can simplify the work of the copy editor, and possibly speed publication of his article, by a careful reading of his final draft for inconsistencies in punctuation and abbreviations and for errors in spelling and typing.

Information in this chapter may aid the author even while he is writing his manuscript and preparing it for publication, but it will be of greatest interest and benefit to him after the manuscript has been set in type—when he receives galley proof and dead copy from the printer. Then it should help him to understand the strange and idiosyncratic world of editors and printers.

SPECIFICATIONS

When a journal is founded and at infrequent intervals thereafter, the editor and the editorial board, perhaps with the aid of a professional designer, establish a set of specifications for the publication: its physical dimensions; the kind and weight of paper on which it is to be printed; the type faces and sizes, leading (spacing between lines of type), measure (length of line), and arrangement (including indentions) for the text, headings, abstracts, tables, legends, footnotes, references, formulas, and equations, and any other kind of material that is to be set in type.

The type face chosen for a journal or book must be suitable for the subject matter, adaptable in meeting the various typographic situations that may be encountered, and acceptable to a majority of its potential readers. A face suitable for biological publications should be available not only in the roman lightface in which most text matter is set but also in italics, small caps, and boldface.

Although many type faces are available, the present tendency is for a journal to use only two or three faces: possibly a display face for titles of articles and a body type in its various forms (lightface, boldface; roman, italic; capitals, lowercase, and small capitals) for all other matter.

In the United States, two of the important printing specifications are stated in units of measure common in this country: the weight of the paper in pounds and the overall size of the page in inches. Others are stated in the special units of the printing industry and are based on the point system. A point is 0.0138 (about 1/72) inch.

Units of the point system and their approximate English and metric equivalents are as follows:

1 point = 1/12 pica = 1/72 inch = 0.35 mm
1 pica = 12 points = 1/6 inch = 4.2 mm
6 picas = 72 points = 1 inch = 25.4 mm

The em is a linear unit of variable measurement that had its origin in the width of the capital M. In type of any size, it is equal to the height of the type, including ascenders and descenders; in 10-point type it is 10 points and in 8-point it is 8 points. The en is half an em. One em is a common paragraph indention and a common indention for a runover or turnover line; it is the paragraph indention in this manual.

Whereas the overall size of a page in a journal or book is expressed in inches, the dimensions of a type page (the printed part of the page), an illustration, or an engraving are stated in picas.

Spacing between characters, between words, and between lines of type is specified in points. Spacing between columns on a page of text may be specified in ems or in picas. The thickness of rules used in printing is stated in points, the length in picas.

Body type is available in several sizes and in many faces. Most articles in scientific journals are set principally in 10-point type, usually with 1- or 2-point leading. This paragraph is set in 10-point type with 2-point leading (10 on 12 or 10/12).

This sentence (except the first letter) is set in lowercase 6-point roman (not italic).

This line, in 8-point type, contains CAPITALS and SMALL CAPITALS.

This line, in 10-point type, contains *italic* and **boldface.**

This line is in 12-point type.

This line is in 18-point type.

The chapter titles in this manual are in 24-point Helvetica, caps and lowercase. The rule below each title is ½ point thick and 27 picas long (the overall width of the type page).

Type for the text, headings within chapters, legends for illustrations, tables, and other matter is Times Roman, which was cut originally for the *Times* of London.

The size of type for most of the text is 10 point with 2-point leading (specified as "10 on 12 Times Roman"). The measure is 23 picas. The "examples" are set in 9 on 10.

The first two levels or grades of headings within chapters are distinguished by differences in size of type, letterspacing (spacing between letters), and leading above and below the headings. The third level (rare) is a run-in sidehead set in italics.

Legends for figures are set in 9 on 10. Most tables are in smaller type than the text; the rules in tables are ½ point thick; their length varies with the number of columns they cover.

The running heads for the verso or even-numbered pages are set in 10-point Times Roman small caps. Those on the recto or odd-numbered pages are in 10-point Times Roman italic caps and lowercase. Folios (page numbers) are in 10-point roman (not italic). The depth of the standard type page, including the running heads, is 42 picas.

TYPOGRAPHICAL CONVENTIONS

Certain typographical conventions that developed over the years have become widely accepted by editors and printers, writers and readers. Some of the conventions relating to capital and small capital letters, to italic and roman and boldface type, have special meanings in science. Any biologist writing for publication should know the common as well as the specialized conventions (see Chapter 4) and how the kinds of type are indicated.

Although the copy editor marks the manuscript pages for sizes of type, measure, leading, and similar specifications, the author is responsible for marking italics, small capitals, and other technical style conventions peculiar to his area of research.

Typesetters are trained to follow copy scrupulously, and a manuscript will be set as typed or marked except, of course, for printer's errors. For example, your typed lines will be set lightface roman, the capital letters as capitals, the lowercase as lowercase, the words as you have spelled them, unless a copy editor or you show, by marks the printer understands, that they should be otherwise. Each correction mark should be in or directly above the line being corrected, and not in the nearest margin as on proof.

The most important of the typographical conventions understood and accepted by editors and printers are outlined below.

ITALICS (marked by single underlining)

Italics are used for

1) the title of a book or a periodical mentioned in the text. In a few scientific journals and most books, such titles are italicized in bibliographies also.

2) most foreign words and phrases and their abbreviations, but not proper names. Many words and abbreviations of foreign origin are no longer regarded as foreign and are not italicized: a priori, in vitro, in vivo, i.e., et al.
3) an unknown or a constant in mathematical matter.
4) the scientific name of a genus, species, subspecies, or variety. The name of a higher taxon is usually not italicized.
5) a letter or number used in the text or in a legend to refer to a corresponding character in an illustration.
6) a word or term introduced for specific discussion (its first occurrence only).
7) a word used as a word, as in "For two reasons *we* is italicized."
8) a letter used as a symbol for a gene or allele, but not for a chromosome or blood group.
9) a word or phrase to be emphasized (overuse destroys the emphasis).
10) a title for a table or a legend for a figure (in some journals).
11) a cross-reference expression in an index: *see* and *see also.*

SMALL CAPITALS (marked by double underlining)

Small capitals are used

1) for certain abbreviations to help distinguish them from other abbreviations having identical letters: M (molar), N (normal), D and L in configurational prefixes, SD (standard deviation), SE (standard error).
2) in combination with capitals to give typographic variety in some journals, as for running heads, FIG. in legends, TABLE in headings.

The use of small capitals is being discouraged by editors of many biological journals because it usually entails an additional and often unjustifiable expense.

CAPITALS (marked by triple underlining)

An initial capital or initial capitals are used for

1) a proper noun and usually for a proper adjective. (A letter typed as a capital need not be underlined.) Some words

that have been derived from proper nouns and that have a specialized meaning are not capitalized:

petri dish	roman type	bunsen burner
paris green	italicize	pasteurize

2) the first word of each sentence except when it is in parentheses or brackets within another sentence.
3) certain words in the titles of articles and books: (i) the first and last words and all others except coordinating conjunctions, prepositions, and articles that are not first or last words, or (ii) the first word and all proper nouns and adjectives. The second style is more common in bibliographic lists than elsewhere.
4) a professional, civil, military, or religious title or title of nobility that immediately precedes a personal name:

    Senator Fulbright   Captain Hamilton

5) the official name of a private or government organization or institution, but not the shortened form of such a name or an informal reference to it unless necessary to avoid ambiguity:

    Stanford University   the City of Tucson

6) a generic geographical name that is part of a proper name:

    Lake Michigan (*but* lakes Michigan and Erie)
    the Columbia River (*but* the Columbia and Snake rivers)

7) the name of a historical epoch, geologic age or stratum, zoogeographic zone, or other term used for convenience of classification. The terms *age, era, epoch, period, till, glaciation,* and others are not capitalized unless ambiguity might result:

    Neolithic age   Stone Age   Ice Age   Pleistocene epoch

8) the scientific name of a phylum, order, class, family, or genus, but not of a specific or subspecific taxon except where permitted by the botanical code.
9) the complete vernacular or common name of a species of birds in accordance with the checklist of the American Ornithologists' Union (1957).

10) the common name of an insect *only* when in accordance with the list approved by the Entomological Society of America.
11) the name of a star or other astronomical body, except *earth, moon,* and *sun.*
12) a trade name.
13) the first word after a colon if the following words form a complete independent clause that is not logically dependent on the preceding clause.

BOLDFACE (marked by wavy underlining)

Boldface is used for

1) the name proposed for a new genus, species, or subspecies (some journals).
2) a vector in mathematics.
3) the volume number of a periodical listed in a bibliography (some journals). Many journal editors regard boldface for volume number as an expensive and unnecessary convention.

ESTIMATING NUMBER OF PRINTED PAGES

The number of journal pages that will be required to print a manuscript can be estimated by a method known as copy fitting or casting off.

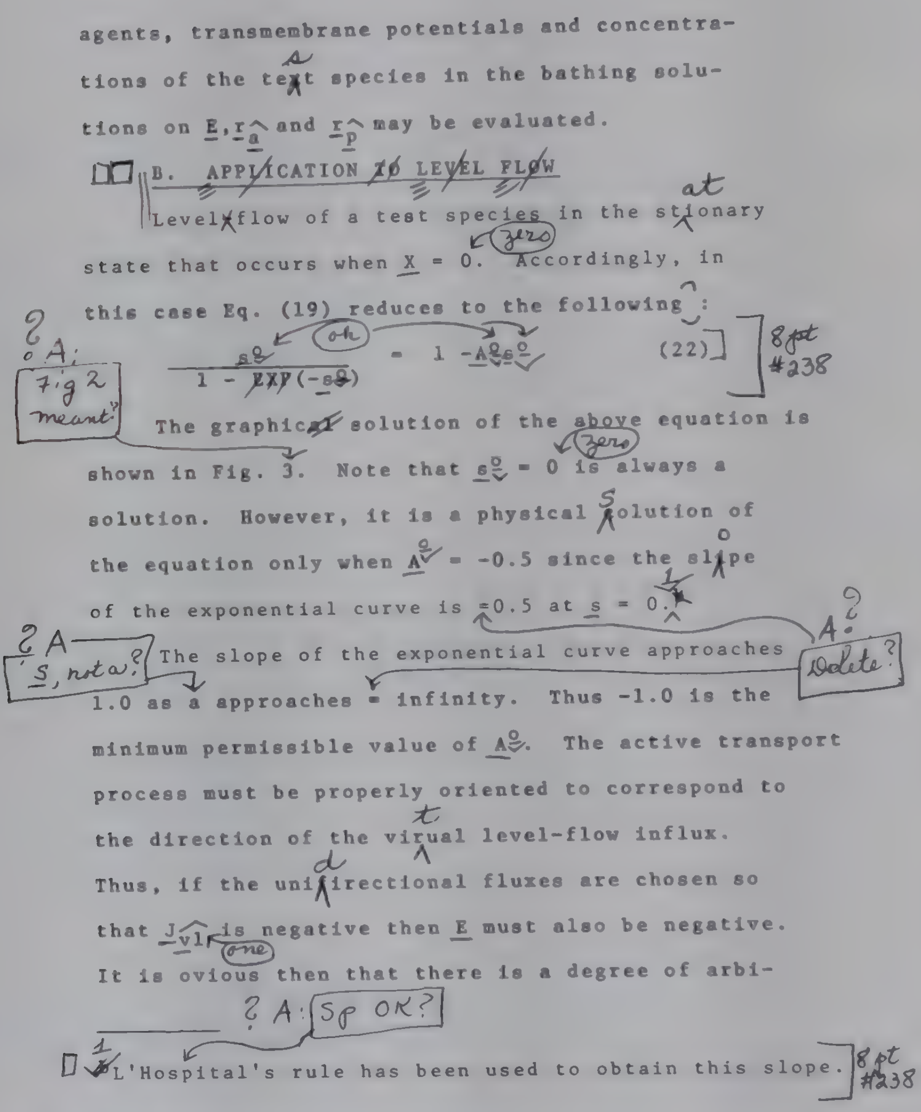
Although characters in printer's fonts are of several widths (*e* and *h* wider than *i* and *l* and narrower than *m* and *w*), they tend to average out. Printers can provide estimates of the number of characters per pica for a font of type of any size used for text.

For example, Times Roman sets 3.05 characters per pica in 8 point, 2.85 in 9 point, and 2.7 in 10 point. A simple formula for computing the number of printed pages from any manuscript is this:

$$\frac{(\text{MS lines/page}) \times (\text{Characters/MS line}) \times (\text{MS pages})}{(\text{Characters/printed line}) \times (\text{Lines/printed page})}$$

COPY EDITED AND MARKED

Below is shown a manuscript page that has been marked for the printer. Some of the marks are used by proofreaders. Directions to the printer may be written in ink of a color different from that used for editorial changes. The printer knows from the specification sheet the type face(s) and the measure to be used for text and other matter.



agents, transmembrane potentials and concentrations of the te~~x~~st species in the bathing solutions on E, r_a and r_p may be evaluated.

B. APPLICATION TO LEVEL FLOW

Level flow of a test species in the stationary state occurs when $X = 0$ (zero). Accordingly, in this case Eq. (19) reduces to the following:

? A: Fig 2 meant?

$$\frac{s^o}{1 - \mathrm{EXP}(-s^o)} = 1 - A^o s^o \qquad (22)$$

8 pt #238

The graphical solution of the above equation is shown in Fig. 3. Note that $s^o = 0$ (zero) is always a solution. However, it is a physical solution of the equation only when $A^o = -0.5$ since the slope of the exponential curve is -0.5 at $s = 0.$¹

? A: Delete?

? A 's, not a?' The slope of the exponential curve approaches 1.0 as a approaches infinity. Thus -1.0 is the minimum permissible value of A^o. The active transport process must be properly oriented to correspond to the direction of the virtual level-flow influx. Thus, if the unidirectional fluxes are chosen so that J_{v1} (one) is negative then E must also be negative. It is ovious then that there is a degree of arbi-

? A: Sp OK?

---

¹L'Hospital's rule has been used to obtain this slope.

8 pt #238

Fig. 1. A page of edited manuscript with queries from the editor to the author, "A."

9. Proof

INTRODUCTION

If your article is to be printed by letterpress, type is set on a linotype or monotype machine and stored temporarily in long metal trays called galleys. Proof of type in the galleys is mailed to you for checking.

The galley proof is the first indication you have of how your article will appear in type. It may be the only proof you see, inasmuch as few journals supply authors with page proof—proof of type that has been corrected and assembled in pages. For several reasons, including quality of paper, impressions on galley proof are not so clear or distinct as those on a printed page.

At the top of each sheet of galley proof are letters and numerals that include the number of the galley and other information essential to the printer. Do not cross them out or cut them off. They will be deleted when the pages are made up. In the margins of the sheet you may find queries, suggestions for changes, and corrections by the editor or a proofreader. Do not erase or obliterate any mark on any galley proof (see "Marking Proof," this chapter). Even though you find the proof sheets inconveniently long to handle, do not cut them.

If your article is to be printed by offset, either (i) the text is set in type, as for letterpress, and you are sent galley proof, or (ii) it is specially typed on a variable spacing typewriter and you are sent, instead of proof, the newly typed pages, each mounted on cardboard and covered with an overlay of transparent paper. Make no marks on the typed pages (see "Correcting Typewriter Composition," this chapter).

With the galley proof, or the pages of typewriter composition, will be included your original typescript, now called *dead, foul,* or *set copy*. Add no marks whatsoever to this dead copy. Because it is the typescript as it was received by the printer, it is the basis for the billing of author's and editor's alterations.

The recently introduced photocomposition by computer-driven machines may eventually replace much of the conventional metal type composition. In photocomposition a coded tape is made from the typescript. The tape, after being checked for accuracy, is used as input to a composing machine, which quickly produces films from which proofs can be made. Because such proofs are usually not of as good quality as those pulled from metal type and, moreover, are very expensive, printers are likely to limit the quantity of proof they provide the author—sometimes even submitting none at all. An author whose article is to be photocomposed should take great care to have his typescript letter-perfect.

READING PROOF

Read the galley proof at least twice. Read it word for word the first time with another person holding copy and reading aloud from it. Verify all unusual words and terms, all proper names, numerical data, bibliographic references, and the like. Make corrections as described in "Marking Proof," this chapter.

Read it the second time alone, looking especially for inaccuracies of statement in the typescript as you submitted it and as it was edited. Correct the inaccuracies but do not regard the proof as a place for making trivial changes, for improving your style, for adding new material, or for making deletions.

If in reading proof you recognize that, since submitting your typescript, you have made discoveries or observations so important and pertinent that you believe they should be reported in or with your article, add this material only if you inform the editor that it is new. To include new material in an article under an old "received" date is unethical. If the editor agrees that the new material should be added, he may suggest either a later date for your article or a dated addendum containing the new material. Such an addendum, which can be inserted between the body of the article and the list of references, obviates the need for changes in the text proper.

Either in the first or second reading or in a special inspection of the galley proof, check the dividing or breaking of words at the ends of lines (see "Checking Word Division," this chapter).

MARKING PROOF

To reset a line of type costs more than to set it initially, because it involves hand work as well as composition. Correcting a line set on a linotype machine requires resetting the entire line on a slug of metal, removing the incorrect slug by hand, and replacing it with the new one. Correcting a line set on a monotype machine also requires hand work—pulling out characters and replacing them with others.

Printer's errors (type deviations from the original copy) are corrected at no cost to the journal or the author, but changes made by the author are charged to the journal and may ultimately be charged to the author. Any printer's errors you detect should be indicated as such on the proof.

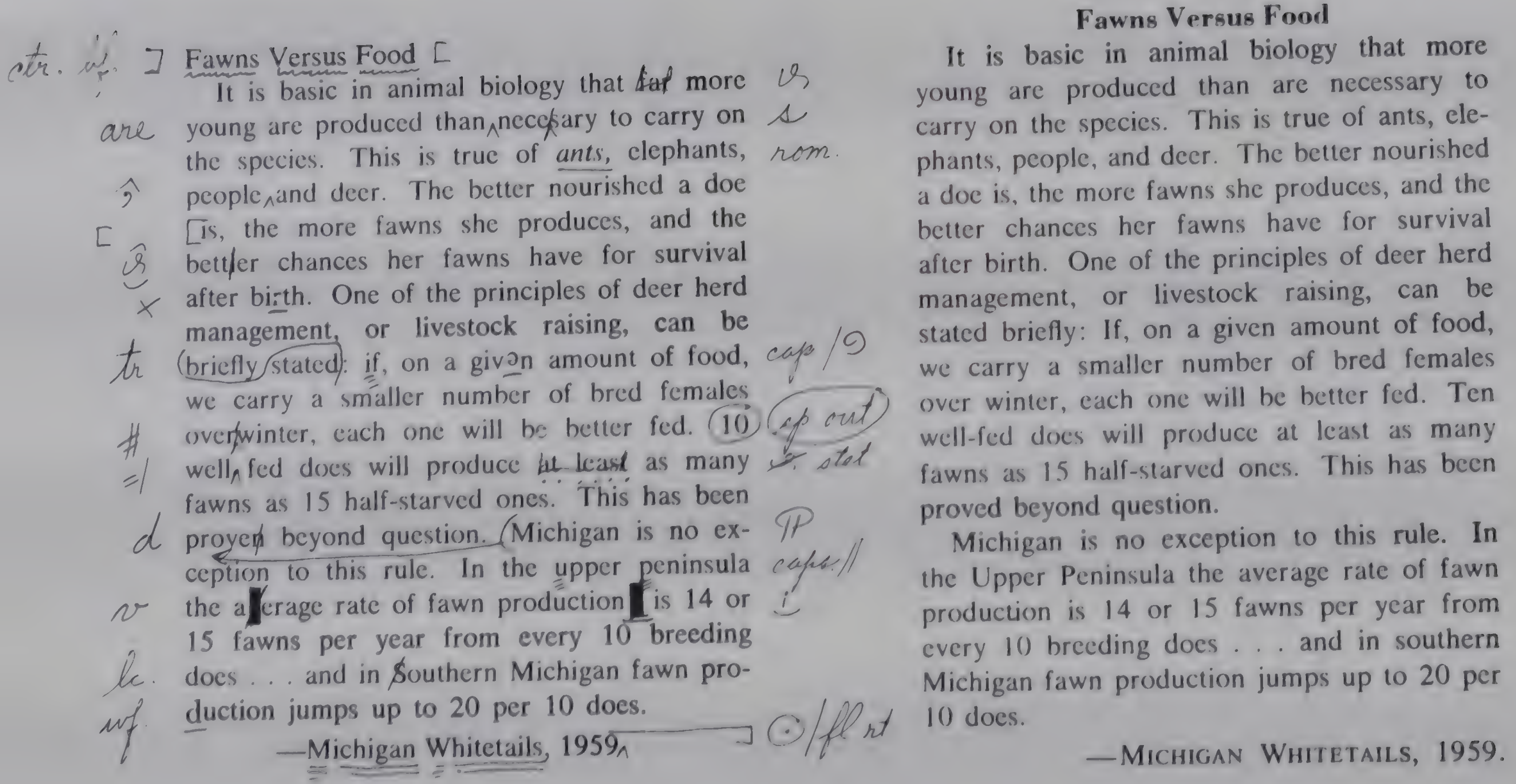
In marking proof, use the proofreader's marks shown on pages 190–191. Make the corrections in colors different from any already on the proof. For example, if the printer's proofreader has marked corrections in green, indicate the printer's errors in red and your alterations in blue.

For each correction, you must make at least two marks on the proof: one or more in the text (*in-line*) and one or more in the nearer margin (*marginal*), as on page 192. One of the in-line marks may be a caret (∧) to show where an addition is to be made; another may be a line drawn through a character or a word to be deleted. A marginal mark indicates what the change

PROOFREADER'S SYMBOLS AND MARKS

Instruction	*Marginal Mark*	*In-Line Mark*	*Corrected Type*
Delete	₰	the ~~red~~ book	the book
Close up	⌢⌣	the bo‿ok	the book
Delete and close up	⌢₰⌣	the bo~~o~~ok	the book
Restore deletion	stet	the ~~red~~ book	the red book
Insert in line	red	the‸book	the red book
Substitute in line	red e	the ~~black~~ book th~~a~~ book	the red book the book
Insert space in line	#	the‸book	the book
Equalize spacing	eq #	the ✓yellow✓book	the yellow book
Lead (space) between lines	ld >	→The red book was lost.	The red book was lost.
Remove leads between lines	less #	(The red book was found.	The red book was found.
Begin new paragraph	¶ ¶	‸The red book was lost. ⌐The black ‸book was found.	The red book was lost. The black book was found.
Run paragraphs together	run in	The black book was lost. ⊃ ⊂The red book was found.	The black book was lost. The red book was found.
Insert 1-em quad	⊐ □	□The red book	The red book
Insert 2-em quad	⊐ □□	□□was found	was found
Insert 3-em quad	⊐ □□□	□□□at night.	at night.
Move to left	⊏	⊏ the book	the book
Move to right	⊐	the book ⊐	the book
Center	⊐ ⊏	⊐ the book ⊏	the book
Move up	⊓	⊓the book⊓	the book
Move down	⊔	⊔the book⊔	the book
Align vertically	‖	|The book was lost in the fog.	The book was lost in the fog.
Align horizontally	=	The book was read.	The book was read.
Transpose	tr tr	The found book was Teh book was found.	The book was found. The book was found.
Spell out	two	The 2 books came.	The two books came.
Push down quad	⊥	the▪book	the book
Reset broken letter	×	the book	the book

Instruction	*Marginal Mark*	*In-Line Mark*	*Corrected Type*
Turn right side up	9	the booʞ	the book
Lowercase letter	lc.	the /Green book	the green book
Capitalize as marked	caps.	the good book	the Good Book
Set in even small caps	sm. c.	se, SD	SE, SD
Set in italic type	ital.	The Good Book	*The Good Book*
Set in roman type	rom.	the *book*	the book
Set in boldface type	bf.	The Good Book	**The Good Book**
Set in lightface type	lf.	the **book**	the book
Set in caps & s.c.	c.+s.c.	A Style Manual	A STYLE MANUAL
Set in boldface italic caps & l.c.	bf. ital. c+lc	a style manual	***A Style Manual***
Wrong font; reset	wf	body type	body type
Reset as superscript	$\overset{2}{\vee}$	the book|2	the book^2
Reset as subscript	$\overset{\wedge}{2}$	H|2S	H_2S
Insert as superscript	$\overset{b}{\vee}$	120,738∧	120,738^b
Insert as subscript	$\overset{\wedge}{2}$	H∧O	H_2O
Insert or substitute punctuation mark			
Period	⊙ ⊙	Read the book∧ Read the book|	Read the book. Read the book.
Comma	$\overset{\wedge}{,}$	leaves, buds∧and branches	leaves, buds, and branches
Semicolon	$\overset{\wedge}{;}$	Think| then decide.	Think; then decide.
Colon	:	Read the following∧	Read the following:
Hyphen	=/	up∧and∧down career	up-and-down career
Apostrophe	$\overset{,}{\vee}$	Land∧s End	Land's End
Double quotes	$\overset{“}{\vee}$/$\overset{”}{\vee}$	He said∧book.∧	He said "book."
Single quotes	$\overset{‘}{\vee}$/$\overset{’}{\vee}$	"Don't cry∧Fire∧!"	"Don't cry 'Fire'!"
Question mark	?	Can you write|	Can you write?
1-en dash	$\frac{1}{n}$	pages 10|15	pages 10–15
1-em dash	$\frac{1}{m}$	The book|find it	The book—find it
3-em dash	$\frac{3}{m}$	Ito, R. I. 1967. An ~~Ito, R. I~~. 1970. The	Ito, R. I. 1967. An ———. 1970. The
Parentheses	(/)	the book∧a manual|	the book (a manual)
Asterisk	$\overset{*}{\vee}$	the book∧	the book*
Dagger	$\overset{\dagger}{\vee}$	6,731∧	6,731†
Slant line	/	5 m|s	5 m/s



ctr. bf] Fawns Versus Food [
It is basic in animal biology that ~~far~~ more
are young are produced than^necessary to carry on s
the species. This is true of *ants,* elephants, rom.
, people^and deer. The better nourished a doe
[[is, the more fawns she produces, and the
bettler chances her fawns have for survival
× after birth. One of the principles of deer herd
management, or livestock raising, can be
tr (briefly stated): if, on a givən amount of food, cap /9
we carry a smaller number of bred females
# overwinter, each one will be better fed. (10) sp out
=/ well^fed does will produce ~~at least~~ as many stet
fawns as 15 half-starved ones. This has been
d proven beyond question. (Michigan is no ex- ¶
ception to this rule. In the upper peninsula caps//
v the a▮erage rate of fawn production ▮ is 14 or i
15 fawns per year from every 10 breeding
lc. does . . . and in Southern Michigan fawn pro-
wf duction jumps up to 20 per 10 does.
—Michigan Whitetails, 1959^ ⊙/fl rt

Fawns Versus Food

It is basic in animal biology that more young are produced than are necessary to carry on the species. This is true of ants, elephants, people, and deer. The better nourished a doe is, the more fawns she produces, and the better chances her fawns have for survival after birth. One of the principles of deer herd management, or livestock raising, can be stated briefly: If, on a given amount of food, we carry a smaller number of bred females over winter, each one will be better fed. Ten well-fed does will produce at least as many fawns as 15 half-starved ones. This has been proved beyond question.

Michigan is no exception to this rule. In the Upper Peninsula the average rate of fawn production is 14 or 15 fawns per year from every 10 breeding does . . . and in southern Michigan fawn production jumps up to 20 per 10 does.

—MICHIGAN WHITETAILS, 1959.

Galley proof. The left column shows a block of proof marked for corrections; the right, the proof after the corrections have been made.

is to be. It may be one or more characters or words to be inserted, or a proofreader's symbol, such as a space or deletion sign. Each mark should be made on an imaginary extension (left or right) of the line to which it applies. To indicate several corrections for a single line, arrange them in sequence from left to right in the nearer margin and separate adjacent corrections by a perpendicular stroke.

In correcting galleys, a typesetter or a compositor scans the margins of the proof and makes only the alterations he finds indicated there. On page 192 is shown proof of type that has been corrected in accordance with the proofreader's marks on pages 190–191.

If your correction or insertion involves more than one or two lines, type it on a separate sheet and attach the sheet to the galley proof at the appropriate place with tape, never with paper clip or pin. Show clearly where the new copy is to be inserted.

Make all corrections neatly and legibly. Do not issue blanket orders such as "Set *Rosa* in italics throughout," and do not expect the printer to make corrections you write in an accompanying letter.

Look for question marks on the proof sheets. Give an unambiguous answer to every query from the editor or printer. If you want the type to remain as set, draw a line through the question mark, but do not erase it. If the editor or a proofreader has indicated a change you cannot accept, draw a line through the suggested change and write in the margin "OK as set," or write "stet" in the margin and put dots below the material you want retained.

Cooperate with the editor in his efforts to keep the cost of alterations low. If you add material, consider either (i) placing it at the end of a paragraph, (ii) making a separate paragraph of it, or (iii) deleting as many characters as you add (count each space as a character). If you delete material, consider adding the equivalent in number of characters and spaces. An alteration in any line in a paragraph may necessitate resetting all the following lines to the end of the paragraph unless insertion and deletion are equal, character for character.

Indicate on the galley proof an appropriate position for each figure and table by writing a marginal note with a circle around it. (See marginal note on page 170.) Encircle any material you do not want set, such as a note to the editor.

CORRECTING TYPEWRITER COMPOSITION

If, instead of galley proof, you receive pages of typewritten composition, possibly done on a variable spacing typewriter and camera-ready except for illustrations and corrections, *do not make any marks on the paper*. Indicate all changes on the overlay, lightly and with a soft pencil. Be sure the overlay lies straight and flat on each page as you make corrections. In writing on the overlay, take care that your marks will not show on the page itself.

Make corrections as you would in correcting typescript.

Each correction you make requires that the printer have at least part of a line retyped and stripped in by hand. Adding or deleting a word—sometimes even a character—may necessitate the retyping of several lines.

For suggestions that should prove helpful in reading and marking typewriter composition, see "Reading Proof" and "Marking Proof," this chapter.

CHECKING WORD DIVISION

Because of the editorial prohibition against dividing or breaking a word in the typescript, you are not faced with the problem of word division until you receive galley proof or its equivalent. The proof or (in typewriter composition) retyped pages may contain many divided words—part of the word on one line and part on the following line.

In the American system, word division is based on pronunciation, not on derivation of words as in the British system. Most experienced typesetters make few errors in dividing words familiar to them. In checking divided words, you should be concerned principally with uncommon scientific terms and Latin words.

For division of Latin words see the paragraphs immediately below. For division of others, consult *Webster's Third New International Dictionary* (1961) or *Webster's Seventh New Collegiate* (1963); *A Manual of Style,* published by the University of Chicago Press (1969); or *Proofreading and Copy-Preparation* by Lasky (1954). If you find words on which the two *Websters* disagree, follow the division in the *Collegiate,* which represents later thinking on the subject.

Every Latin word is divided into as many syllables as it has separate vowels and diphthongs. The consonant *h* between two vowels always joins the second vowel (*mi-hi, co-hors*); *x* between two vowels always joins the preceding vowel (*sax-um, ax-il·la*); *ch, ph,* and *th* are never separated (*Te-thys*); *gl, tl,* and *thl* are always separated (*Ag-la·o·ne·ma, At-las, ath-let·i·cus*). A single consonant between the last two vowels of a word or between any two unaccented vowels joins the final or second vowel (*pa-ter*); but a single consonant before or after an accented vowel joins the accented syllable (*i-tin′·e·ra, dom′-i·nus*). Two consonants between vowels must be separated (*cor-pus, for-ma*); of three consonants between vowels, the last joins the vowel that follows (*emp-tor*); of four consonants between vowels, two are joined to each vowel (*trans-trum*).

When a compound word is divided into syllables, the component parts are separated if the first part ends with a consonant (*su·per-est, sub-i·tus, trans-i·tur*); otherwise it is divided as if it were a simple word (*dil·i-gens*).

As in other aspects of Latin grammar, some exceptions to the above rules exist, but they are too technical or unusual to merit treatment here.

PROOF OF ILLUSTRATIONS

If your journal is printed by letterpress, you may receive a set of engraver's proof of illustrations with the galley proof of the text. Or you may receive galley proof that shows the engravings and legends assembled, with each legend below the engraving to which it applies.

Do not judge the quality of a halftone engraving by the galley proof, which has less contrast and detail than the halftone will show on the printed page. The engraver's proof, on coated or glossy paper of high quality, is better evidence of the quality of a halftone. But do not expect the impression on the journal page to have the brilliance of the engraver's proof unless the papers are of equally fine quality.

Examine the proof of each line etching for the absence of numerals, letters, lines, or parts of lines that may unintentionally have been routed out by the engraver. Look for letters or numerals that have "filled in" with ink.

Indicate clearly on the engraver's proof any correction you believe should be made in a halftone or a line etching. Certain kinds of flaws in line etchings can be easily corrected by the engraver: superfluous dots and lines can be tooled or routed out; some slightly broken lines and characters can be repaired. The quality of some halftone engravings can be improved by "staging"—further etching in certain areas to increase the contrast. Adding to or otherwise revising a figure necessitates making a new cut.

Identify each figure on the engraver's proof by writing its number beneath it. Write "Top" above the upper margin of each figure in which orientation is not apparent. Check the stated magnification of each figure for which magnification is given.

Return the engraver's proof and the galley proof to the editor. Include the original copy for any cut that is not satisfactory to you.

If your journal is printed by offset, you will not receive engraver's proofs but may receive instead a set of vandykes, silver prints, or blueprints, which are photographic reproductions. Use them to identify your illustrations but not to predict the quality of your figures as they will appear in the journal.

HANDLING PROOF FOR OVERSEAS AUTHORS

Air mail is recommended for any proof that is sent to or by authors living in countries overseas. Because of the cost of air mail and the possible delay in delivery, an author living overseas may delegate to a scientist living in the United States certain responsibilities relating to his article: reading proof, approving or rejecting editorial changes, and returning proof to the editor with an order for reprints.

Xerographic reproductions of copy-edited typescripts are sent by some editors to overseas authors at the time the typescripts are sent to the printer. They should be promptly read, corrected, and returned by the authors; they can be used in correcting galleys if the printing schedule does not allow time for proof to be sent overseas and returned.

10. Indexing

THE APPROACH TO INDEXING

Although indexes for books and bound volumes of journals have long been regarded as integral parts of scientific publication, recent developments have brought about a new appreciation of both indexes and indexing. The constantly increasing quantities of published material and the growing dependence on computers for storage of information have intensified the need for meticulous care in preparing indexes that permit efficient and accurate retrieval.

The author of a technical book is usually expected to prepare or assist in the preparation of the index. Even though the author of a journal article is seldom asked to prepare a separate index for his manuscript, he may be expected to supply key words or phrases to be published with his article, fed to computers, and used later in indexing the annual bound volume. The problems encountered in supplying key words or phrases with manuscripts are somewhat similar to those involved in preparing entries for indexes.

A knowledge of the principles and mechanics of indexing may be helpful to a reader as well as to an author; it should enable him to make maximum effective use of indexes.

THE ELEMENTS OF THE INDEX

An entry, the basic unit of an index, consists of a key word or words, sometimes called a descriptor or a heading, and usually at least one locator, which in most indexes is a page number. Each descriptor should be specific and concise. It may be a single word, or it may consist of several words that provide clues to the reader in judging whether the reference will give him the information he seeks. It should not include unnecessary prepositions or conjunctions—of, on, or, and—that clutter the index.

Both the words selected and their arrangement in the entry must be suited to the interests of the potential reader. The phrase "Physiological effects of audible sounds" would be indexed only if, in the judgment of the indexer, the subject is likely to attract a reader of the journal or book being indexed. The reader of one journal might look for the subject matter under "Physiological effects of audible sounds" and the reader of another under "Audible sounds, physiological effects." The indexer must decide which word order is preferable for his journal.

The descriptors "Phosphonomycin, structure and synthesis," and "Birth control agents, chemical, prognosis for development," appear to be reasonable ones for almost any journal or book published for scientists.

Helpful advice on indexing can be found in books listed in the bibliography, Chapter 13, at the end of this manual, but ultimately the indexer must depend on common sense, a retentive memory, imagination, and a considerable capacity for taking pains.

THE MECHANICS OF INDEXING

The general principles and procedures followed in compiling indexes are approximately the same for all types of publications.

The first task of an indexer who is not the author is to read the entire work and to familiarize himself with it sufficiently to make tentative decisions, possibly with the help of the author, about the categories or classes of items to be indexed. If the author is the indexer, he should make the decisions, possibly with the help of an editor. For the index to a large taxonomic work on an insect group, the names of all genera and species should, of course, be included. But should place names of collecting sites, types of habitat, and food plants also be indexed? Such questions should be answered before the indexing is begun.

The preliminary reading of a work may be from galley proof, but the actual indexing should be done from the page proof. The indexer reads the pages of proof consecutively and with close attention, beginning with the first page. When he reads a word or phrase that he decides should be indexed, he types it on a card and adds a comma and the number of the page on which he has found the item. He may reword a phrase to place the most important word first. To show that the word or phrase has been typed on a card, he may underline it on the page proof.

The common 3-by-5-inch (7.6-by-12.7-centimeter) filing cards, one card for each entry, are suitable for indexing. Long, perforated strips of card stock that can be torn apart to make 3-by-5 cards are also suitable; they are convenient for typing and handling.

The cards are allowed to accumulate in the order in which they are typed. If the indexer has an afterthought about a card already typed, he should not search for the card to retype the entry or add to it. Instead, he should type a new card and keep it with the other cards he is working on.

If he finds at any time that he must revise his tentative list of categories to be indexed, adding a category or dropping one, he should record the number of the page on which he makes the change and continue reading pages consecutively. Later he should search preceding pages for items in any added category. He should, of course, destroy all cards for items in a category that has been eliminated.

When the last card for the last page has been typed, the indexer sorts the cards into 26 assemblages according to the initial of the first word of the entry. He then proceeds to alphabetize the *A* cards, next the *B* cards, and so on, through the *Z*'s. Of the two methods of alphabetizing, the word-by-word system may be adequate for nontechnical publications. The letter-by-letter or dictionary system is almost imperative for volumes containing acronyms, letters and symbols having technical meanings, and expressions involving typographic conventions in special fields; it is a convenient system for managing comparatively simple problems presented by compounds—solid, open, and hyphenated. Below are listings by the two systems:

Word-by-word	*Letter-by-letter (dictionary system)*	
Acid chloride	Acid chloride	Crossbill
Acid number	Acidemia	Cross dating
Acid test	Acid-fast stain	Cross-fertile
Acidemia	Acidic mine drainage	Cross hair
Acid-fast stain	Acid number	Cross-reference
Acidic mine drainage	Acidosis	Cross section
Acidosis	Acid test	Crossvein

In either system of alphabetizing, conventions peculiar to the nomenclature in a given field or a given publication should be respected.

Certain appendages, numerical or literal, having special meanings in chemistry are included in the indexes of many technical books but are disregarded in alphabetizing. Among them are arabic numerals; Greek letters; such italicized expressions as *d, l, m, meta, o, ortho, p, para, s, sec, sym, syn, t,* and *tert;* a capital letter that is the symbol for a chemical element and that, italicized, has a special meaning; and the small capital letters D and L. As a prefix, one of these expressions is attached to the name by a hyphen; within a name, it is preceded and followed by a hyphen.

Because of the typographic limitations of computer printouts, both *Biological Abstracts* and *Chemical Abstracts* deviate from the practices described above. No Greek letters and no subscript or superscript symbols are reproduced in the indexes. In *Biological Abstracts,* an abstract of a paper on "β-1 receptor mediated responses" can be located through the "Subject Index" under "Beta 1 receptor mediated responses." In the "Keyword Subject Index" of *Chemical Abstracts,* the standard positional and isomeric locants are rarely used; "*cis*-cinnamic acid" in the abstract appears in the index as "cinnamic acids" and "2-

butanol" as "butanols." An abstract on γ-aminobutyric acid is indexed under "Gamma aminobutyrate," and one on ^{131}I under "Iodine 131."

In editing the cards, the next step in indexing, the indexer must be on the alert to recognize and reconcile the almost inevitable overlappings, discrepancies, and inconsistencies that come to light, once the cards have been alphabetized. He must devote particular attention to three details on which the usefulness of the index depends: the wording of the descriptor in each entry (discussed briefly in the first part of this chapter), the placement of the comma(s) in the entry, and the markings to guide the compositor for indention.

If in the *E* cards the indexer comes to a card reading "Encephalitis, aerial transmission of, 100," it is his responsibility to remember an entry among the *A* cards that reads "Aerial transmission of disease, 97–102"; the card is one of a group with that descriptor, all but the first of which carries a subdescriptor. Four of the six subdescriptors name a disease, but encephalitis is not one of them; the two other subdescriptors concern atmospheric conditions and other determinants of aerial transmission of disease. The minimum action the indexer should take is to insert a card among the *A*'s reading "Aerial transmission of disease, encephalitis, 100." If he decides to retain the "Encephalitis" card as well, he should make four more cards, one for each of the other diseases, each card with the subdescriptor "aerial transmission" and the proper page number(s), and file it in its alphabetical niche.

On each card the items of the entry are separated by commas:

Encephalitis, aerial transmission of, 100

The transition from typed cards to printed index is mediated by the indexer's instructions to the compositor who sets the type; it is best explained by an example:

Cards	*Index*
Hair, 12	Hair, 12
Hair, auditory, 93	auditory, 93
Hair, chemoreceptive, 95	chemoreceptive, 95
Hair plate, 85	Hair plate, 85
Hairstreak, *see* Lycaenidae	Hairstreak, *see* Lycaenidae

The indexer deleted the repeated key word, "Hair," from the second and third cards and substituted the mark for an em-quad space, "□," to indicate a 1-em indention for the subentry. He did not delete "Hair" from the last two cards because it is not followed immediately by a comma; the word is only part of the descriptors "Hair plate" and "Hairstreak." The *see* cross-reference instead of a page number tells the reader that all information on hairstreak is to be found under the name of the family to which the butterfly belongs.

The sample index shown above is in the indented style, common in technical books. An excerpt from a run-on or run-in index, usual in books on history and related fields, is given below. The source is a scholarly two-volume work on Abraham Lincoln.

Lovejoy, Owen, endorses Helper, I, 132; on administration's policy toward fugitive slaves, II, 131; mentioned, 211, 217.

THE TYPOGRAPHY OF INDEXES

The tendency among modern editors and book designers is to simplify the typography of indexes and to avoid capital and small capital letters for names of authors, dashes of various lengths as substitutes for indention, and boldface or italic type for volume numbers or for pages containing principal references or illustrations (unless the illustrations are very important). In most technical indexes, particularly indented indexes, the established conventions, properly observed, are capable of conveying the desired information effectively without the aid of special typographic devices.

11. Word List

This list was begun as a collection of words frequently misspelled or misused by biologists. It was enlarged to include many more words—compounds (open, closed, hyphenated) and terms used by biologists in highly specialized disciplines but possibly unfamiliar to other scientists.

The spelling is based on current preferences in the United States. For a few words the British spelling is given also. An *or* between words indicates equal status for the spellings or forms; an *also* implies a preference for the first spelling or form. Most of the words followed by definitions or comments are at least occasionally misused; some were contributed by readers of previous editions of the *Style Manual for Biological Journals*.

The list is necessarily selective and to some degree reflects the experiences of the compilers—members of the committee responsible for the present edition of the manual. For spelling and usage of many words, the committee members consulted *Webster's Third New International Dictionary of the English Language, Unabridged* (1961), Fowler and Gowers (1965), and Follett (1966). For scientific terminology, they depended principally on indexes of *Biological Abstracts* and *Chemical Abstracts,* reports of nomenclature committees of specialized disciplines, and pertinent publications of such national and international organizations as the American National Standards Institute and the World Health Organization.

Some of the entries illustrate principles of spelling that can be applied to other words. The spelling of compound terms and derivatives is discussed in Chapter 3 of this manual. The spelling of derivatives is treated on pages 23a–25a in the front matter of *Webster's Third,* and rules for doubling or not doubling a consonant before a suffix are clearly stated on page 69 of the *Style Manual* published by the United States Government Printing Office (1967).

Users of this list are reminded that language is a developing art, that idiom changes, and that communication is the desired end.

abscissa, *plural* abscissas, *not* abscissae

absorbance: *ability of a layer of a substance to absorb radiation;* absorptance *is the proportion of radiant energy absorbed by a layer of the absorbing material*

absorbency: *the state or quality of being absorbent*

absorptance: *see* absorbance

absorption: *an assimilation or taking up by capillary, osmotic, chemical, or solvent action; distinguish from* adsorption

acclimate, acclimatize: *for the distinction between these words see the discussion under* harden *in Webster's Third*

accuracy: *degree of correctness of a measurement or a statement; do not confuse with* precision

acetylcholine

ACTH: *abbreviation for* adrenocorticotropin, adrenocorticotropic hormone, *or* corticotropin *as given in report of IUPAC-IUB Combined Commission on Biochemical Nomenclature (J. Biol. Chem. 241: 533–537); the same spellings have been adopted by Biological Abstracts and Chemical Abstracts; see* tropic, trophic

Adrenalin: *a trade name; use* epinephrine *unless the specific product is to be designated*

adsorption: *through physical or chemical forces, a taking up by the surfaces of solids or liquids; distinguish from* absorption

affect: *as verb, to produce an effect or to influence; as noun in psychiatry and psychology, feeling tone accompanying an idea or mental representation; a generic term for feeling, emotion, or mood*

after, *adverb: following in time or place; see* following

aftereffect, afterpotential

agenda: *as singular noun, an outline of subjects to be discussed, a plan of procedure; plural* agendas

agglutinin-adsorption, *not* agglutinin-absorption

airbrush, *noun or verb*

air-condition, *verb;* air-conditioned, *adjective;* air conditioner, *noun*

airflow, air gauge, airstream, *nouns;* airtight, *adjective*

albumin: *any of a large class of simple proteins, but* albumen, *the white of an egg*

alga, *plural* algae

algal, *adjective: relating to alga or algae*

all right, *not* alright

ambience, *noun: surrounding atmosphere or environment; in scientific usage preferred to* ambiance

ambiens, *plural* ambientes: *a thigh muscle of certain birds* ambient: *as noun, environment or encompassing atmosphere; as adjective, surrounding or encompassing*

amino acid, *but* aminoaciduria

Amoeba, scientific name of a genus; the name capitalized and italicized

ameba (*plural* amebas) *or* amoeba (*plural* amoebae), *common name*

among, *preposition: used in comparing more than two things; see* between

analogue, *or, in computer-science terminology,* analog

analyze, *preferred to* analyse

anesthesia, *preferred to* anaesthesia

ante: *as prefix meaning before, earlier, or anterior, combines without hyphen, as in* antemortem; *distinguish from* anti

antero: *combining form meaning situated toward the front; opposed to* postero; *combines without hyphen, as in* anteroparietal

anti: *against, opposed to; as prefix combines without hyphen except before a base word beginning with a capital* (anti-Stokes line) *or an* i (anti-icer); *distinguish from* ante

anticholinesterase

autolysate, autolysis, *nouns;* autolyze, *verb*

autopsy: *postmortem examination; synonym of* necropsy

autoradiograph, *not* radioautograph

axenic, *adjective: refers usually to living organisms maintained in isolation from all other living things, or to their environment; see* gnotobiotic

Bacillus, scientific name of a genus; the name capitalized and italicized

bacillus, *common name, plural* bacilli

back flow, backflux

Bacterium, scientific name of a genus; the name capitalized and italicized

bacterium, *common name, plural* bacteria; bacterial, *adjective*

baker's yeast, bakers' yeast: *in phrases of this kind the position of the apostrophe varies with the dictionary and the phrase; it could be standardized if all authors and editors would consider the first element in its generic sense; then* brewer's grains, camel's hair, cow's milk, confectioner's sugar, hen's eggs, miner's worm

band form; band pass, *but* band-pass filter; bandwidth

barbotage: *method of dissolving drug in withdrawn spinal fluid, for spinal anesthesia*

base line, *noun;* base-line, *adjective*

baseplate

basis, *plural* bases

between, *preposition: used in comparing two things; see* among

bioassay, *noun or verb*

biopsy

biuret: *a chemical compound;* biuret reaction; burette, buret, *a laboratory apparatus*

blender, *a mechanical device for blending materials;* Waring blender *is now acceptable*

bloodstream

bone screw

border line, *noun;* borderline, *adjective*

brainstem, brainpower; *but* brain wave

breakdown, *noun*

break up, *verb;* breakup, *noun*

breath-holding, *noun or adjective*

brewer's yeast *or* brewers' yeast: *see* baker's yeast

bromosulfalein: *generic term is* sulfobromophthalein sodium; *also known by various trade names, including* Bromsulphalein

bromothymol blue, bromocresol green, bromocresol purple

Büchner funnel, *after Ernst Büchner*

Buchner hydraulic press, *after Eduard Buchner*

build up, *verb;* buildup, *noun;* built-up, *adjective;* built-in, *adjective*

burette *or* buret: *laboratory apparatus*

bypass, *noun or verb, but* by-product, by-reaction

Cactus, scientific name of a genus; the name capitalized and italicized

cactus, *common name, plural* cacti *or* cactuses

calyx: *part of a flower, plural* calyxes *or* calyces; *but* calix, calices, *ecclesiastical chalice(s)*

cancel, canceled, canceling, *but* cancellate, cancellus, cancelli, cancellous

cannot

carcass, *plural* carcasses

case: *an episode or instance of disease or injury; frequently misused in clinical journals for* patient, *the ill person*

catalog, cataloger, cataloging, cataloged; *generally preferred to* catalogue, cataloguer, cataloguing, catalogued

catalysis, *noun;* catalyze, *verb*

catecholamines

cellophane

changeover, *noun;* change over, *verb*

chi-square, *noun or adjective*

chloroacetic, *preferred to* chloracetic

cholinesterase

chromatography, *not* chromotography; *but* chromotypography

circadian, *adjective: approximately one day*

clathrate, *adjective: shaped like a lattice; descriptive of certain compounds*

coauthor, *noun or verb; but* co-worker

cocarboxylase

Coccus, scientific name of a genus; the name capitalized and italicized

coccus, *common name, plural* cocci

cod-liver oil

compare, *verb: followed by* to *when a similarity is stated or suggested, as in* He compared Mendel to Washington (*one the father of a science, the other the father of his country*); *followed by* with *when details of similarity or dissimilarity are stated or suggested, as in* He compared Mendel with Darwin, *that is, pointed out or suggested details in which the two scientists were similar or dissimilar*

controlled, controlling

cooperate, cooperation

coordinate, *noun or verb*

corn oil, *but* cornmeal

countercurrent

co-worker, *but* coauthor

criterion, *plural* criteria

criticize

crossbill, cross-immunity, cross cell, *nouns;* cross-reference, *noun, verb, or adjective;* cross-link, crossover, cross vine, crossvein, *nouns;* cross section, *noun;* cross-section, *verb or adjective; for many other words beginning with* cross *consult an unabridged dictionary*

crystalline, crystallize

curriculum, *plural* curricula *also* curriculums

cutoff, *noun or adjective;* cut off, *verb*

cytochrome *c, a, etc.*

dark-eyed, dark-haired, *adjectives*

dark field, *noun;* dark-field, *adjective, as in* dark-field microscope

darkroom

data, *plural of* datum

data processing

daylight, *noun or adjective*

deep-rooted, deep-seated, *adjectives*

demarcation, *preferred to* demarkation

demonstrate, *see* exhibit

deoxy, *chemical prefix; not* desoxy, *which is British usage*

desiccate, desiccator

determine: *do not use as synonym for* analyze; *not* the chemist determined eight soil samples *but* the chemist determined the pH of eight soil samples

detoxication, detoxification, *alternative spellings*

diagramed *or* diagrammed, diagraming *or* diagramming, *but* diagrammatic

dialysis, *plural* dialyses; dialyzate *or* dialysate: *product of dialysis;* dialyze: *to subject to dialysis;* dialyzer: *apparatus for dialysis*

die: *preferred to* expire, succumb, *and other words substituted as mere euphemisms*

die-away, *noun or adjective;* die away, *verb;* die-off, *noun;* die off, *verb*

different from, *preferred to* different than

dilatation: *the act or anatomic result of dilating;* dilation: *only the act of dilating*

dimer, *noun: chemical compound; but* dimmer, *adjective, comparative of* dim, *or noun, a mechanical device*

disk, *usually preferred to* disc

display: *see* exhibit

distill

diurnal

dot-raster: *a term in computer science*

double cross, *noun;* double-cross, *verb*

downstroke

drug: *a* drug *is* administered, given, taken, withdrawn; *a* drug *is not* "started" *or* "stopped," *but rather its use;* drug therapy *is* started, drug treatment *is* begun

due to: *careful writers with a feeling for word history tend to avoid using* due to *and* owing to *except as modifiers of substantives* (coughs due to colds); *they use instead such phrases as* because of, on account of, by reason of; due *and* owing *are grammatically alike* (due *a past participle and* owing *a present participle*), *and yet for many years linguists who found fault with* due to worry he sleeps badly *accepted* owing to worry he sleeps badly; *in Webster's Third,* due to *belatedly received equal status with* owing to; *both terms are now recognized as compound prepositions—but careful writers will probably not use them as such*

earache, earlobe, earmark, earwax, ear snail, ear tree, ear trumpet

eclosion: *in insects, the act of hatching or emerging*

effect, *verb or noun; see* affect

effluent: *something that flows out;* effluence: *usually a flowing out;* effluent *is preferred in technical and scientific writing; the original distinction between these two words is useful*

eigenfunction, eigenstate, eigenvalue

electric, electrical: *note* electric potential, electric shock, electric wave, *but* electrical drainage, electrical engineer; *see discussion of* ic, ical *in this list and consult dictionary when in doubt*

electromagnetism, electromyogram

electron microscope, electron optics, electroosmosis, electron-optical

eluate, *washings obtained by eluting;* eluent *or* eluant, *solvent used in eluting;* elute, eluted, eluting *are the verb forms*

embed, *preferred to* imbed

embryo, *plural* embryos

embryonic, *preferred to* embryonal

enable: *do not use as substitute for* permit

end feet, end line, end point

endemic, *noun or adjective: refers to a human disease constantly present to some extent in an area; see* enphytotic *and* enzootic; *contrast with* epidemic *and* sporadic

enphytotic, *noun or adjective: refers to a disease of plants; analogous to* endemic *and* enzootic

ensure: *to make sure or guarantee*

envelop, *verb;* envelope, *noun*

enzootic, *noun or adjective: refers to a disease of infrahuman animals; analogous to* endemic

enzymatic *or* enzymic

epidemic, *noun or adjective: refers to a disease rapidly affecting many humans in an area at one time; see* epiphytotic *and* epizootic; *compare* endemic

epiphytotic, *noun or adjective: refers to a disease simultaneously affecting many plants (usually of one kind) in an area*

epizootic, *noun or adjective: refers to a disease simultaneously affecting many animals of the same kind in an area*

equilibrium, *plural* equilibriums *or* equilibria

estrogen, *noun: preferred to British* oestrogen

estrus, *noun;* estrous, *adjective: preferred to British* oestrus, oestrous

etiology: *study or description of causes of a disease*

exhibit: *one of a number of verbs* (demonstrate, display, expire, reveal, succumb, visualize, *and others*) *sometimes used as elegant, pompous, or euphemistic substitutes for more familiar and commonly accepted words; such words are justified only when they are specifically suited to the situation under discussion and are used sincerely and honestly—they should not be used to impress readers or to soften unpleasant facts; example:* the patient exhibited anemia *as an elegant or pompous substitute for* the patient had anemia

expire: *see* die *and* exhibit

extracapsular, extracellular

eyeball, eyebrow, eyepiece, eyespot, eyelash, *but* eye color, eye gnat, eye lens, eye worm, eye-opener; *consult dictionary for other* eye *terms*

eyepiece micrometer

facilitative: *do not confuse with* facultative

farther, *adjective or adverb: more distant in time or space, or divergent in use; see* further

fasted: *do not use as euphemism for* starved, *as in* the rats fasted, *or* the rats were fasted, for 10 days; *fasting is usually considered a voluntary act*

feedback, *noun*

female: *avoid unnecessary use in clinical journal as substitute for* woman *or* girl

ferrous: *refers to compounds containing iron having a valence of two;* ferric: *refers to compounds containing iron having a valence of three or more*

fetus, *plural* fetuses

fingerprint, fingertip, *but* finger fracture, finger grass, finger joint, *and* finger-shaped

flip-flop

flotation, *not* floatation

flow chart, flow line, *but* flowmeter

fluorescein, *a dye*

fluorescent: *having, or characterized by, fluorescence*

fluoridate: *to add a fluoride compound, as to drinking water;* fluoridize: *to treat with a fluoride compound as in dentistry;* fluorinate: *to introduce fluorine into a chemical compound in synthesis*

focus, focused, focusing, *verb*

focus, *noun; plural* focuses *or* foci

fold: *a suffix that, with a numerical term spelled out, forms a solid word* (sevenfold); *that with an arabic numeral or numerals forms a hyphenated term* (14-fold)

following: *Webster's Third recognizes this word as both an adjective and a preposition; Fowler (1965:204) discourages its use as a preposition; to avoid ambiguity, as in* following the lecture, the student ate his luncheon, *substitute* after *for* following

foot-binding, foothill, footlambert, foot louse, footnote, foot soldier, footstalk, foot-and-mouth disease, *nouns;* footloose, *adjective*

forebrain, forehead, forefoot, foreleg, foreset, foreword, *but* fore wing

former *and* latter: *do not use when referring to more than two antecedents*

Formalin: *a trade name; use* formaldehyde solution *unless reference is to the specific product*

formula, *plural* formulas

fourfold: *see* fold

free: *as verb or adjective, often followed by* with, *sometimes by* of (*see Webster's Third*); *as suffix, usually combines with a hyphen, but* germfree *and* carefree *are solid*

free radical

freeze-dry, *verb;* freeze-dried, *not* froze-dried *or* frozen-dried

freeze dryer, *noun*

freezing point, *noun;* freezing-point, *adjective, as in* freezing-point law

fuller's earth; *see* baker's yeast

fungal *or* fungous, *adjective*

fungus, *noun; plural* fungi

further: *as adjective, additional, going beyond what exists; as adverb, in addition, moreover, more distant; as verb, to promote or advance; see* farther

gage, *noun or verb: see* gauge

gallbladder, gallnut, gallstone; *but* gall midge, gall mite, gall oak

gastrointestinal, gastrovascular

gauge: *noun or verb associated with measurement;* gauge *was the original spelling, but* gage *has become standard in some technical fields—* air gauge, pressure gauge, shotgun gauge, *but* gage block, gasoline gage, railroad gage, gage the velocity of a stream

gelatin: *preferred to* gelatine

genus, *plural* genera

germ band, germ cell

germfree: *specific laboratory connotation*

Gladiolus, scientific name of a genus; the name capitalized and italicized

gladiolus, *common name; plural* gladiolus, gladioli, *also* gladioluses

glucose-6-phosphate; glucose-6-phosphate dehydrogenase

gluten

glutaraldehyde

glycerin: glycerol *preferred*

gnotobiotic: *refers to laboratory animals specially reared and germfree except for known microorganisms with which they have been inoculated; see* axenic

gram-negative, gram-positive, *adjectives*

Gram stain *or* Gram's stain, *after Hans C. J. Gram*
gray: *preferred to British* grey; *but* greyhound

half-life, *noun or adjective*
half time, *noun;* half-time, *adjective*
halftone, *in photoengraving*
halfway, *adjective and adverb*
headphone, headpiece
heartbeat, *but* heart block, heart failure
hemacytometer
hematin, *preferred to* hematine
hematopoiesis
hematoxylin
hemoglobin, hemoglobin A, hemoglobin S, *and others*
hemogram: *a clinical term referring to blood counts and other laboratory studies used to characterize a patient's hematologic condition; particular tests used should be specified*
hemorrhage, *noun or verb*
hemorrhoid
heterophil, *noun or adjective; preferred to* heterophile
hindbrain, hindfoot, hindgut, hindleg; *but* hind end, hind kidney, hind wing
Hippuran: *a trade name for* o-iodohippurate sodium
homoeologous, *adjective: refers to partially homologous chromosomes; do not confuse with* homologous
homologue *or* homolog
human, *noun or adjective;* human being *sometimes preferred as noun*
hydrolysis, *plural* hydrolyses; hydrolyzate *or* hydrolysate, *product of hydrolysis;* hydrolyze, *to subject to hydrolysis;* hydrolyzer, *apparatus for hydrolysis*
hypothesis, *plural* hypotheses; hypothesize, *verb: to assume, form a hypothesis—not to be confused with* hypothecate, *a legal term meaning to pledge*

ic, ical, *suffixes: these two word endings often convey identical meanings* (microscopic examination, microscopical examination) *but sometimes different meanings* (economic botany, economical process); *when in doubt about the proper suffix, consult a reliable dictionary*
ideomotor
identical: *often followed by* with, *rarely by* to
idiogram: *diagrammatic representation of a karyotype*
idiokinetic
imbed: embed *preferred*
imply: *often confused with* infer; *the speaker* implies; *the hearer* infers
incidence: *number of cases developing per unit of population per unit of time, as in* 100 cases of tuberculosis per 100,000 persons per year; *do not use for* prevalence, *number of cases existing per unit of population at a given time*
indeterminacy
index, *noun and verb: as plural noun,* indexes *for a book,* indices *in mathematics*
indicator-dilution curve
indole
infer: *see* imply
infrared
inkwriter
innocuous
inoculum, *plural* inocula; inoculate, *verb*
inpatient: *patient in a hospital or infirmary who receives food and lodging in addition to treatment; distinguished from* outpatient
insanitary, *adjective: not sanitary; in medical idiom, preferred to* unsani-

tary, *especially if the connotation injurious to health is intended*

insure: *to assure against loss; underwrite; give, take, or procure insurance; do not use for* ensure, *in the sense of guarantee or make sure*

inter: *as prefix meaning between or among, combines without hyphen* (interrelate) *except when preceding a capital letter* (inter-European)

intra: *as prefix meaning within or inside of, combines without hyphen* (intracardiac, intracranial) *except before a word beginning with an* a (intra-atomic) *or a capital letter* (intra-European)

juvenile, *noun or adjective:* juvenal *sometimes preferred in wildlife research*

karyotype, *noun: a systematized arrangement of the chromosomes of a single cell, typical of an individual or a species; see* idiogram

karyotypic, *adjective: representative of a karyotype or pertaining to it*

Kjeldahl flask; kjeldahlize

kneebrush, kneecap, knee jerk, knee joint, *nouns;* knee-deep, knee-high, knee-jointed, *adjectives*

Krebs cycle: tricarboxylic acid cycle *preferred*

Krebs-Henseleit cycle: ornithine cycle *preferred*

Krebs-Ringer solution

label, labeled, labeling

lacquer

landfall, landfill, landflood, landform, landholder, landmark, landmass, landowner, landslide, *but* land bridge, land crab, land cress, land lead, land measure, land snail, land tortoise, *all nouns*

landlocked, land-grant, *adjectives*

Langendorff technique

laser

leukemia, leukocyte, *preferred to* leucemia, leucocyte

lifeboat, lifelong, lifework, *but* life buoy, life plant, life preserver; *and* life-form, life-size, life-span

like, *suffix: compound words formed with this suffix are solid* (lifelike, eellike), *unless the suffix follows a word ending in* ll (shell-like), *or a long word* (pleuropneumonia-like) *or a proper name* (June-like) *or a hyphenated word* (half-ape–like)

lipid, *noun: preferred to* lipide *or* lipin; *one of a group of fats and fatlike substances; see* lipoid

lipoid, *adjective:* fatlike

lipoprotein

liquefy, *preferred to* liquify

littermate

live trap, *noun;* livetrap, *verb*

logic unit

lumen, *plural* lumens *preferred to* lumina *if reference is to unit of luminous flux; adjective form is* luminal

luminance

lyophilize

lysis, *plural* lyses; lysate: *product resulting from lysis*

male: *use as adjective (not noun) in reference to a patient* (a jaundiced male patient, *not* a jaundiced male)

mannite: *use* mannitol

matrix, *plural* matrices (*mathematics*) *or* matrixes (*printing trade*)

maximum, *plural* maximums *or* maxima; maximal, maximum, *adjectives*

media, *plural* mediae: *middle layer of a blood or lymph vessel; median vein of an insect's wing; see also* medium

medium, *plural* media *or* mediums: *use of* media *as a singular noun, as in* television is a more effective advertising media than radio, *is jargon*

meiosis, *plural* meioses: *the chromosomal rearrangement in a cell leading to production of two new cells, each having half the normal number of chromosomes, as in production of gametes; do not confuse with* miosis

micro-Kjeldahl

microorganic, microorganism, micropodal

microphotograph: *a photograph on a greatly reduced scale, as on microfilm; do not confuse with* photomicrograph, *a photograph taken through a microscope*

midday, midline, midpoint, midrib, *but* mid-carpal, mid-latitudes

migrate: *do not use as a transitive verb;* the birds migrated, *not* the current migrated the bacteria

millenary, *noun: a group of 1,000 units or things; period of 1,000 years;* millenary, millenarian, *adjectives*

millennium, *noun; plural* millennia *or* millenniums: *period of 1,000 years;* millennial, millennian, *adjectives*

milli: *prefix meaning thousandth; combines without hyphen*

minimum, *plural* minimums *or* minima; minimal *or* minimum, *adjectives*

miosis, *plural* mioses: *excessive smallness of the ocular pupil; do not confuse with* meiosis

mitosis, *plural* mitoses: *a type of cell division*

molal, molar; molality, molarity: *not synonymous; the* al *forms refer to molecular concentration per 1,000 grams of solvent, the* ar *forms to molecular concentration per 1,000 milliliters of solution*

mold, *noun or verb, preferred to British* mould

morphology: *the study of form or structure*

mouthparts (*of an insect*)

mouthpiece

mucin: *one of a group of mucoproteins found in various secretions and tissues of humans and infrahumans*

mucous, *adjective*; mucus, *noun*

multi: *prefix meaning much or many; combines without a hyphen*

necropsy: *postmortem examination; synonym of* autopsy

neoprene: *a synthetic rubber,* polychloroprene

Nessler's reagent, Nessler's test, Nessler tube, *nouns;* nesslerize, *verb*

neuron, *preferred to* neurone

ninhydrin

non: *as an English prefix, combines without a hyphen except before a capitalized word* (non-British) *or a hyphenated word* (non-self-governing); *some editors advocate inserting a hyphen between* non *and a word beginning with* n *if the hyphen is likely to contribute to clarity*

nosebleed, noseclip, *but* nose drops

oasis, *plural* oases

oestrus, oestrous: *see* estrus

off-color, *adjective;* offshoot, *noun;* offshore, *adverb or adjective*

optimal, optimum, *adjectives*

optimum, *noun; plural* optima *or* optimums

orient: *as a verb, usually preferred to* orientate

ornithine cycle, *preferred to* Krebs-Henseleit cycle

osmolal, osmolar; osmolality, osmolarity: *not synonymous; see* molal
outpatient: *a person who is not a patient in a hospital but who receives clinical diagnosis or treatment; distinguished from* inpatient
over: *as prefix, forms solid words*
overall, *noun and adjective*
owing to: *see* due to
oxalacetic acid, *preferred to* oxaloacetic acid; *but* oxalosuccinic acid

pandemic: *widely epidemic; refers to disease in human beings*
panzootic: *widely epizootic; refers to disease affecting animals of many species*
paper chromatogram, *preferred to* papergram
parameter: *has a special meaning in mathematics; do not use loosely for* variable, quantity, quality, determinant, *or* feature
pathological, *of the field of pathology;* pathologic, *having the qualities studied in pathology,* abnormal; *see* ic, ical
pathology: *the study and description of disease processes, abnormalities, and lesions; do not use for* abnormalities *or* lesions
patient: *an ill person in the care of a physician or hospital; see* case
percent, *noun, adjective, or adverb: some journals use symbol with number, as in 98%*
percentage, *noun: part of a whole expressed in hundredths, as in* percentage of cells; *often used as an adjective,* percentage error
petri dish, *or* Petri dish, *after Julius R. Petri, German bacteriologist*
phagocyte, *noun;* phagocytic, *adjective;* phagocytosis, *noun, plural* phagocytoses; phagocytize, phagocytose, *verbs*
phenomenon, *plural* phenomena *or* phenomenons; *see Webster's Third*
phosphorus, *noun; plural* phosphori: *sometimes used attributively as in* phosphorus research; phosphorous: *used as adjective to mean resembling phosphorus or to designate a compound of phosphorus in which this element has a valence lower than that in phosphoric compounds*
photochemistry
photomicrograph: *a photograph taken through microscope; do not confuse with* microphotograph
photoperiod
phylum, *plural* phyla
physical chemistry, *noun; adjective:* physicochemical
physiological: *of the field of physiology; see* ic, ical
pipette, *noun or verb: usually preferred to* pipet; pipetting, pipetted
plasmapheresis *preferred to* plasmaphoresis: *method of plasma depletion by removing blood, centrifuging out cells, and returning them in a suitable liquid medium*
plasmolysis: *shrinkage of protoplasm of a cell as a result of loss of water by osmosis*
polarization
poly, post, pre, *prefixes: most words formed with these prefixes are solid; exceptions are those containing proper nouns or their derivatives, as* pre-Darwinian
postmortem, *noun or adjective;* post-mortem, *adverb, as in* three cases examined post-mortem
precision: *in science, degree of refinement with which a measurement is made or stated; do not confuse with* accuracy; *the number 3.43 shows more precision than 3.4, but it is not necessarily more accurate*
prevalence: *number of cases per unit*

of population at a given time; see incidence

preventive, *preferred to* preventative

print-out (*in photographic printing*) *or* printout (*in computer science*), *noun;* print out, *verb*

Protozoa: *scientific name of a phylum of simple animals; note roman (not italic) type and capital letter*

protozoan, *common name, plural* protozoans: *one of the Protozoa; preferred to* protozoon, *plural* protozoa; protozoan, protozoic, *adjectives*

proved, *usually preferred to* proven *as past participle;* proven *sometimes used in negative* (not proven) *and in an attributive position* (a proven method)

radio: *as a prefix, usually combines without hyphen*—radioactive, radiobiologist, radiocarbon, radiograph, radionuclide, radiopaque; *but* radio proximity fuse, radio range station, radio telescope; radio frequency, *noun;* radio-frequency, *adjective; see Webster's Third*

radioautograph: *use* autoradiograph

radius, *plural* radii

rarefy: *preferred to* rarify

react: *do not use as transitive verb, as in* he reacted the two reagents

reveal: *see* exhibit

rhythmic: *marked by pronounced rhythm;* rhythmical: *pertaining to or involving rhythm; see* ic, ical

Ringer's solution *or* Ringer solution, *after Sydney Ringer*

sagittal

sea level

self: *as prefix, usually combines with a hyphen; see Webster's Third*

separatory funnel *or* separating funnel

septum, *plural* septums *or* septa; *but* septum transversum, *plural* septa transversa

sequela, *plural* sequelae: *aftereffect of disease or injury*

serology: *a science associated with serums; use of* serology *for* serological test *should be discouraged*

serum, *plural* serums *or* sera

servomechanism, servomotor; *but* servo brake, servo control, servo system, servo valve

setup, *noun;* set up, *verb*

sidearm, *adjective or adverb;* side arm, *noun*

silica gel, *but* Silica Gel-G *as trade name*

sizable *also* sizeable

skillful *or* skilful, *adjective;* skillfully *or* skilfully, *adverb*

soma, *plural* somata *or* somas: *the body of an organism except its germ cells*

sporadic, *adjective: scattered, occurring occasionally*

sporebearer, sporeformer, sporeforming; *but* spore ball, spore case, spore fruit, spore print, spore sac

steam-distill, *verb;* steam distillation, *noun*

stereospecific

stereotaxis, *noun;* stereotactic, *adjective;* stereotactically, *adverb*

stigma, *plural* stigmata *or* stigmas

stoma, *plural* stomata *or* stomas

stop bath, stop clock, stop light, stop net, stop valve; stop-off; stopback, stopgap, stopover: *see an unabridged dictionary for other words beginning with* stop

sub, *prefix: usually combines to form a solid word* (*without hyphen*); *a few exceptions are* sub-clan *and* sub-society, *nouns;* sub-zero *adjective;* sub-Atlantic, *adjective* (*the base word begins with a capital letter*)

succumb: *see* die *and* exhibit
syllabus, *plural* syllabi *or* syllabuses
symptomatology: *a branch of science that treats of symptoms of diseases; not a synonym for* symptoms *and* signs; *see* exhibit

tapeworm; *but* tape grass, tape measure
taproot; *but* tap screw, tap water
taxon, *plural* taxa *also* taxons
technique, *or* technic; technics *may be used as plural or singular noun to mean the collective methods and devices making up a technology*
temperature: *not equivalent to fever;* the patient had a fever, *not* the patient had a temperature
that: *relative pronoun introducing a restrictive clause* (this is the information that we need); which: *relative pronoun introducing a nonrestrictive clause* (these data, which I have discussed, were obtained at great cost); *see "That and Which," Chapter 2.*
theory: *do not substitute for* idea, concept, opinion; *see* exhibit
thiamine
thioglycolate
thionine
threefold: *see* fold
thyrotropin, thyrotrophin; *see* tropic, trophic
thyroxine
titer, *preferred to* titre
titrate, titration
torr, *plural* torr; *a unit of pressure named for Evangelista Torricelli, inventor of the barometer*
torrefy, *preferred to* torrify: *to dry or roast with fire*
trademark, *but* trade name
transguanylation
tricarboxylic acid cycle, *preferred to* Krebs cycle
tris buffer: *trivial name for* 2-amino-2-hydroxymethyl-1,3-propanediol; *also known as* tromethamine (*USAN name*), TRIS (*code name*), Tris Amino (*trade name*); *avoid use of tris alone* as common noun
tropic, trophic, *adjectival suffixes: both* trop *and* troph, *combining forms used as suffixes or prefixes, are from Greek words; the first is from* trope, *a turning, affinity for; the second is from* trophe, *food or nourishment*
turnover frequency, turnover number
Tween 80: *a trade name for* polysorbate 80 *or* polyoxyethylene sorbitan monooleate
twofold: *see* fold

U shape, *noun;* U-shaped, *adjective*
ultra, *prefix: most words with this prefix are solid, as* ultracentrifuge *and* ultraviolet, *but* ultra-atomic
un, *negatory prefix: most words beginning with this prefix are solid; exceptions:* un-ionized, *to avoid confusion with* unionized (*organized in a labor union*); un-Ionic, un-American, un-British, *but note* unchristian, *in which the capital letter is not retained; consult an unabridged dictionary*
uni, *prefix: words with this prefix are solid, including* uniunivalent
unsanitary, *adjective: not sanitary; see* insanitary

various: *of different kinds or aspects*
varying: *synonymous with* changing *or* causing to change
vertebra, *plural* vertebrae *also* vertebras
viral, *adjective;* virus, *noun, often used attributively as in* virus disease

virial, virial coefficient: *terms in physics*

virion: *virus particle*

visualize: *to make or become visible, to picture mentally; not a synonym for* demonstrate *or* reveal

washout, *noun;* wash out, *verb*

water: *many compound words that begin with* water *are open* (water bath, water vapor), *some are solid* (waterfowl, waterline), *and some are hyphenated* (water-resistant, water-soluble); *Webster's Third contains many more examples*

wave: wave form, wave guide, wave height, wave mechanics, wave number, *nouns;* wave-built, wave-cut, wave-mechanical, wave-worn, *adjectives;* wavelength, wavemark, wavemeter, *nouns*

weekday, weekend

which: *see* that

while: *for use as conjunction, see "While, Although; Since, Because," Chapter 2*

wildlife, wildfowl, *but* wild canary, wild duck

windbreak, windfall; *but* wind drift, wind motor, wind tunnel

work curve, work load, *but* workboat, workday

write off, *verb;* write-off, *noun*

write out, *verb;* write-out, *noun, analogous to* printout *in computer science*

Xerox, *trade name*

xerography, *not* zerography

X ray, *noun;* X-ray, *verb and adjective; the noun used informally for* X-ray photograph *or* X-ray picture; roentgenograph *or* radiograph *preferred*

Y form, *noun;* Y-shaped, *adjective*

zero drift, zero group, zero hour, zero time, zero potential, *nouns; but* zerovalent, *adjective*

zwitterion: *an ion charged both positively and negatively;* dipolar ion *preferred*

12. Abbreviations

Abbreviations and symbols, used sparingly and with good judgment, save time for authors and readers and aid comprehension of readers—especially, for example, when they substitute for cumbersome chemical names or complex phrases.

In this chapter, distinctions are made between standard and nonstandard abbreviations and symbols. As understood here, standard abbreviations and symbols are those that have been agreed upon by one or more international nomenclatural bodies.

In some journals, many of the standard abbreviations—those for units of measure or for certain well-known compounds as, for example, ACTH—are used without definition; however, standard abbreviations peculiar to a restricted field of biology and likely to be unfamiliar to potential readers in related fields are defined at first mention in an article. In many journals, all abbreviations other than those for metric units are defined at first mention.

Nonstandard abbreviations and symbols (those not approved by one or more international nomenclatural bodies) include some that are widely used by practitioners in subdisciplines (for example, BUN for blood urea nitrogen) but are not familiar to most readers in the life sciences; they also include abbreviations that are coined for convenience in a particular paper. The nonstandard abbreviations and symbols should be defined at first mention in an article, or they may be grouped, with their definitions, in a prominent place near the beginning of the article.

Authorities for the standard abbreviations in this chapter (for full names, titles, and details of publication see Chapter 14, "Literature Cited") are the following: a paper on the international system of units by Paul (1971); a manual of symbols and terminology for physicochemical quantities and units adopted by the IUPAC Council which appeared as a paper by McGlashan (1970); a synopsis of the recommendations of the IUPAC-IUB Commission on Biochemical Nomenclature (Sober 1970); the International Union of Biochemistry (1965) recommendations on the nomenclature and classification of enzymes.

The first of the two lists in this chapter contains only abbreviations and symbols that are standard. The second includes abbreviations and symbols that are not standard as well as those that are. The first list is designed primarily for authors, the second for copy editors; but authors, copy editors, and readers will find both lists helpful.

Some abbreviations in the two lists may not coincide with recommended abbreviations in specialized fields as given in Chapter 4. The author confronted with two different abbreviations should attempt to ascertain the one adopted by the journal for which he is writing.

In general, metric units of measure are to be preferred to nonmetric units. Authors and copy editors are referred to Table 2, Chapter 3, for conversion factors, which should be used with caution in changing from nonmetric to metric units. In some articles both metric and nonmetric measures may be given; authors and editors should exercise judgment in deciding when this practice might be justifiable.

Additional explanatory information for a symbol or term is enclosed in parentheses. SI refers to a unit in the Système International.

The warning against an excess of abbreviations (see "Abbreviations and Symbols" in Chapter 3) should be reviewed; an overabundance of even the standard abbreviations may make for heavy reading.

AUTHOR'S GUIDE TO STANDARD ABBREVIATIONS AND SYMBOLS

absorbance; absorbancy: A
acceleration due to gravity: g
acetate: OAc
acetyl: Ac
N-acetyl: NAc
acetyl coenzyme A: CoASAc; acetyl-CoA
N-acetylgalactosamine: GalNAc
N-acetylglucosamine: GlcNAc
activity, relative (thermodynamic): a
acyl coenzyme A: acyl-CoA
adenosine: Ado; A (in combinations)
adenosine 5′-phosphates: AMP, ADP, ATP
adenosine triphosphatase: ATPase
ad libitum: ad lib.
adrenocorticotropic hormone: ACTH
alanyl: Ala
ampere: A (SI base unit)
ampere hour: A·h
ampere second: C (coulomb)
ampere second per volt: F (farad)
angstrom: Å (10^{-1} nm)
arabinose residue: Ara
arginyl: Arg
asparaginyl: Asn
asparaginyl or aspartyl: Asx
aspartyl: Asp
atomic mass unit: u
atto: a (SI prefix, 10^{-18})
Avogadro constant: N_A; L
bar: No abbreviation (10^5 Pa)
barn: b (10^{-28} m^2)
benzoyl: Bz
benzyl: Bzl
blood pressure: BP
boiling point: bp
candela: cd (SI base unit)
candela steradian: lm (lumen)
carboxyhemoglobin: HbCO
carboxymyoglobin: MbCO
Celsius; degree Celsius: C; °C
centi: c (SI prefix, 10^{-2})
coulomb: C (SI derived unit)
cubic meter: m^3
cubic millimeter: mm^3
curie: Ci
cycle per second (electromagnetic): Hz; otherwise, cycle/s
cysteinyl: Cys
cystinyl (half): $\overset{|}{\text{Cys}}$, $\underset{|}{\text{Cys}}$
cytidine: Cyd; C (in combinations)
cytidine 5′-phosphates: CMP, CDP, CTP
deci: d (SI prefix, 10^{-1})
deka: da (SI prefix, 10^1)
density: d; ρ
deoxy: d (in nucleotides)
deoxyribonuclease: DNase
deoxyribonucleic acid: DNA
dextrorotatory: d
diffusion coefficient: D
2,4-dinitrophenyl: DNP (in semisystematic and trivial names); Dnp (with amino acid symbols)
dyne: dyn (10^{-5} N)
electron volt: eV
farad: F (SI derived unit)
femto: f (SI prefix, 10^{-15})
flavin-adenine dinucleotide: FAD
flavin-adenine dinucleotide, reduced form: $FADH_2$
flavin mononucleotide: FMN
1-fluoro-2,4-dinitrobenzene: FDNB
fructose residue: Fru
furanose: f (suffix)
galactose residue: Gal
gamma: Use microgram, μg

gauss:G
giga:G (SI prefix, 10^9)
gluconic acid:GlcA
glucosamine:GlcN
glucose:Glc (residue); G (as in UDPG and G-6-P)
glucuronic acid:GlcUA
glutaminyl:Gln
glutaminyl or glutamyl:Glx
glutamyl:Glu
glutathione, oxidized:GSSG
glutathione, reduced:GSH
glycyl:Gly
gram:g
guanosine:Guo; G (in combinations)
guanosine 5′-phosphates:GMP, GDP, GTP
heavy chain:H chain
hecto:h (SI prefix, 10^2)
hemoglobin, carboxy, and oxy:Hb, HbCO, HbO_2
henry:H (SI derived unit)
hertz:Hz (SI derived unit)
histidyl:His
hour:h
hydroxylysyl:Hyl
hydroxyprolyl:Hyp
inosine:Ino; I (in combinations)
inosine 5′-phosphates:IMP, IDP, ITP
isoleucyl:Ile
joule:J (SI derived unit)
kelvin:K (SI base unit)
kilo:k (SI prefix, 10^3)
kilogram:kg (SI base unit)
lactose residue:Lac
lambda:Use microliter
lethal dose:LD
leucyl:Leu
light chain:L chain
liter:l (10^{-3} m^3)
lumen:lm (SI derived unit)
lux:lx (SI derived unit)
lysyl:Lys
maltose residue:Mal
mannose residue:Man
maxwell:Mx
mega:M (SI prefix, 10^6)
megacycle per second:MHz
melting point:mp
meter:m (SI base unit)
methionyl:Met
methyl:Me
micro:μ (SI prefix, 10^{-6})
microgram:μg (*not* γ)
microliter:μl (*not* λ)
micromicro:Use pico
milli:m (SI prefix, 10^{-3})
minute:min
minute (arc):′
molar:M
mole:mol
myoglobin, carboxy, and oxy:Mb, MbCO, MbO_2
nano:n (SI prefix, 10^{-9})
newton:N (SI derived unit)
nicotinamide adenine dinucleotide: NAD
nicotinamide adenine dinucleotide, oxidized form:NAD^+
nicotinamide adenine dinucleotide, reduced form:NADH
nicotinamide adenine dinucleotide phosphate, oxidized form:$NADP^+$
nicotinamide adenine dinucleotide phosphate, reduced form:NADPH
nicotinamide mononucleotide:NMN
nucleoside, unspecified:N (*not* X)
ohm:Ω (SI derived unit)
ornithyl:Orn
orthophosphate:P_i
oxyhemoglobin:HbO_2
oxymyoglobin:MbO_2
pascal:Pa (SI proposed unit)
phenylalanyl:Phe
phosphate (other than inorganic):*P*; p
phosphate (inorganic), orthophosphate: P_i
phosphocreatine:*P*-creatine

phosphoenolpyruvate: *P*-enolpyruvate; enolpyruvate-*P*
pico: p (SI prefix, 10^{-12})
poise: P (10^{-1} Pa·s)
prolyl: Pro
pseudouridine: ψrd; ψ (in combinations)
pseudouridine 5′-phosphates: ψMP, ψDP, ψTP
purine nucleoside (unspecified): Puo
pyranose: *p* (suffix)
pyrimidine nucleoside (unspecified): Pyd
pyrophosphate (inorganic): $\mathrm{PP_i}$
rad: Do not abbreviate
radian: rad (SI supplementary unit)
riboflavin 5′-phosphate: FMN
ribonucleic acid: RNA
ribose residue: Rib
ribosomal RNA: rRNA
ribosyl (where needed): r
ribosylnicotinamide residue: Nir
ribosylthymine: Thd; T (in combinations)
ribosyluracil: ψrd; ψ (in combinations)
second: s (SI base unit)
seryl: Ser
siemens: S (SI proposed unit)
sorbose residue: Sor
steradian: sr (SI supplementary unit)
stereochemical configuration: D, L, DL
sucrose residue: Suc
Svedberg unit: S
tera: T (SI prefix, 10^{12})
tesla: T (SI derived unit)
threonyl: Thr
thymidine: dThd; dT (in combinations)
thymidine 5′-phosphates: dTMP, dTDP, dTTP
transfer RNA: tRNA
tris(hydroxymethyl)aminomethane: Tris
tryptophyl: Trp
tyrosyl: Tyr
uridine: Urd; U (in combinations)
uridine 5′-phosphates: UMP, UDP, UTP
valyl: Val
volt: V (SI derived unit)
watt: W (SI derived unit)
weber: Wb (SI derived unit)
xanthosine: Xao; X (in combinations)
xanthosine 5′-phosphates: XMP, XDP, XTP
xylose residue: Xyl

COPY EDITOR'S GUIDE TO ABBREVIATIONS AND SYMBOLS

The following alphabetical list is designed primarily for copy editors as a guide in determining the correct term or definition for an abbreviation or symbol used in a manuscript. (It may also be useful to authors in determining the accepted abbreviation or symbol for a term.) To use the list effectively requires practice after a careful study of the explanations below.

The list includes three types of abbreviations and symbols: *standard* (may be used without definition), *nonstandard* (must be defined at first mention), and *not approved* by the compilers of this list (should not be used). In about half of the entries in this list an abbreviation or symbol is followed by a spelled-out term that defines it; in the other half, a spelled-out term is followed by an abbreviation or symbol.

When you encounter an undefined abbreviation or symbol with which you are not familiar, look for it in the list.

1) If the spelled-out term or definition following the abbreviation is not enclosed in brackets, as in

   DNA: deoxyribonucleic acid

   the abbreviation is *standard* and need not be explained, unless the policy of your journal dictates otherwise.
2) If the spelled-out-term is enclosed in brackets, as in

   HAU: [hemagglutination unit]

   look for an entry in which this term precedes its abbreviation. The status of the abbreviation is then determined as follows:

   a) If you find an entry in which the term is followed by an abbreviation marked with an asterisk, as in

      hemagglutination unit: HAU*

      the abbreviation is *nonstandard* and must be defined at first mention in a manuscript.
   b) If you do not find an entry that begins with the spelled-out term for a given abbreviation, the abbreviation (for example, BBB for blood-brain barrier) is *not approved* and should not be used.

Not every acceptable word with an acceptable abbreviation has been given an entry. For example, most words composed of an acceptable prefix and an acceptable base (such as centigram, millivolt, kilometer, etc.) are not included as entries because they are obvious combinations and too numerous. Use caution and good judgment in writing or accepting abbreviations for words not found in the list. Any abbreviation or symbol that you do not recognize as valid, or that you cannot find in the list, should be referred to the author for explanation.

A footnote is provided on each page to remind you of the meaning of [ ] and *.

A: [acid]; [acre]; [adenosine]; ampere (SI base unit); [angstrom]; [*anno* (in the year)]; [antibody]; [area (thermal physiology)]; one of the blood groups; one of the chromosome groups
A: absorbance; absorbancy; [activity]; area; [atomic mass]
A: [alveolar (respiratory physiology)]
Å: [angstrom]
a: [acre]; [ambient (thermal physiology)]; [ampere]; [*annus* (year)]; [aperture]; [are]; [arterial (respiratory physiology)]; atto (SI prefix, 10^{-18}); [year]
a: acceleration; activity, relative (thermodynamic)
AA: [adenylic acid]
AB: one of the blood groups
about: ca. (*circa*)
abs: [absolute]; [abstract]
absolute: abs*
absorbance; absorbancy: A
absorptance: α (thermal physiology)
abt: [about]
abv: [above]
AC: [acetylcholine]; alternating current
Ac: [acetate]; acetyl
ac: [accelerator (biochemistry)]; [alternating current]
a-c: [alternating current]
acceleration: a (SI derived unit: m/s^2)
acceleration, angular: α
acceleration due to gravity: g
ACE: [acetylcholinesterase]
ace: [acentric (genetics)]
acentric: ace*
acetate: OAc
acetyl: Ac
N-acetyl: NAc
acetylcholine: ACh*
acetylcholinesterase: AChe*
acetyl coenzyme A: CoASAc; acetyl-CoA
N-acetylgalactosamine: GalNAc
N-acetylglucosamine: GlcNAc
ac-globulin: [accelerator globulin]
ACh; Ach: [acetylcholine]
AChe; Ache: [acetylcholinesterase]
acid-fast bacillus: AFB*
acidic dissociation constant: K_a
acre: See Table 2, Chapter 3
acre foot: Convert to meter^3, m^3
acrocentric-telocentric chromosomes: A-T*
ACTH: adrenocorticotropin; adrenocorticotropic hormone
activity, relative (thermodynamic): a
acyl-CoA: acyl coenzyme A
A_D: Dubois area (thermal physiology)
adenosine: Ado; A (in combinations)
adenosine 5′-phosphates: AMP, ADP, ATP
adenosine-ribosylthymine: A-T
adenosine triphosphatase: ATPase
ADH: [antidiuretic hormone]
ad lib.: *ad libitum* (as desired)
ad loc.: [*ad locum* (at or to the place)]
admittance: (SI proposed unit: siemens, S)
Ado: [adenosine]
ADP: adenosine diphosphate; [automatic data processing]
adrenocorticotropic hormone; adrenocorticotropin: ACTH
ADS: [antidiuretic substance]
ae.; aet.: *aetatis* (at the age of) Use English
af; AF: [audio frequency]
AFB: [acid-fast bacillus]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

AFC: [automatic frequency control]
A-ft; a-ft: [acre foot]
ag; agr: [agriculture]
AGC: [automatic gain control]
agriculture: agr*
A·h; Ah; A-h; ah: [ampere hour]
AHF: [antihemolytic factor]
Ahr; ahr: [ampere hour]
AI; A.I.: [artificial insemination]
Ala: alanyl
ALGOL: algorithmic language
ALS: [antilympholytic serum]
alt: alternate; altitude
alternating current: AC
alveolar: A* (respiratory physiology)
AM: amplitude modulation; [arithmetic mean]
am: [amplitude]; attometer
a.m.; A.M.; A.M.: *ante meridiem* (before noon)
ambient: a* (thermal physiology)
ambient temperature and pressure, dry: ATPD*
ambient temperature and pressure, saturated with water vapor: ATPS*
p-aminobenzoate: PAB*
p-aminobenzoic acid: PABA*
p-aminosalicylate: PAS*
p-aminosalicylic acid: PASA*
AMP: adenosine 5′-monophosphate
amp: [ampere]; [amplifier]; [amplitude]
ampere: A (SI base unit)
ampere hour: A·h
ampere second: Use coulomb, C
ampere second per volt: Use farad, F
amp-hr: [ampere hour]
amplitude modulation: AM
amp-turn: [ampere turn]
amu: [atomic mass unit]
anal.: analysis
analytical standard of reagent purity: A.R.; AR
angle, plane: rad (SI supplementary unit)
angle, solid: sr (SI supplementary unit)
angstrom: Å (10^{-1} nm)
angular acceleration: α (SI derived unit: rad/s^2)
angular velocity: ω (SI derived unit: rad/s)
anhyd: anhydrous
ant: [antenna]; [anterior]
ante meridiem (before noon): a.m.; A.M.; A.M.
anteroposterior: AP*
antidiuretic hormone: ADH*
antidiuretic substance: ADS*
antihemolytic factor: AHF*
antilewisite, British (2,3-dimercapto-1-propanol): Use chemical name
antilog: antilogarithm
antilympholytic serum: ALS*
ANTU: [α-naphthylthiourea]
AP: [arithmetic progression]; [anteroposterior]
APE: [anterior pituitary extract]
aperture ratio: *f*/
APF: [animal protein factor]
approx.: approximate(ly)
aq: aqueous
A.R.: AR: analytical standard of reagent purity
ar: [arterial (thermal physiology)]
Ara: arabinose residue
area: A (SI derived unit: m^2); A* (thermal physiology)
Arg: arginyl
arginine residue: Arg
arterial: a* (respiratory physiology); ar* (thermal physiology)

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

artificial insemination: AI*; A.I.*
A_s: [atmosphere, standard]
A·s: ampere second (SI name: coulomb)
ASN: [average sample number]
Asn: asparaginyl
Asp: aspartyl
asparagine residue: Asn
asparagine or aspartic acid residue: Asx
aspartic acid residue: Asp
astronomical unit: AU; A.U.
A·s/V: [ampere second per volt (SI name: farad)]
Asx: asparaginyl or aspartyl
A-T: [acrocentric-telocentric chromosomes]; adenosine-ribosylthymine
At; A-t; amp-turn: [ampere turn]
at: atmosphere, technical (SI derived unit: N/m^2)
atm: atmosphere, normal (SI derived unit: N/m^2)
atmosphere, standard: A_s (SI derived unit: N/m^2)
atomic mass unit (unified): u
atomic number: *z**
atomic weight: at. wt. atomic mass preferred
ATP: adenosine 5′-triphosphate
ATPase: adenosine triphosphatase
ATPD: [ambient temperature and pressure, dry]
ATPS: [ambient temperature and pressure, saturated with water vapor]
atto: a (SI prefix, 10^{-18}, as in attometer, am)
at. wt.: [atomic weight]
AU; A.U.: [angstrom unit]; astronomical unit
audio frequency: AF*
automatic data processing: ADP*
automatic frequency control: AFC*
automatic gain control: AGC*
AV; av; A-V; a-v: [arteriovenous]; [atrioventricular]
av; avdp: [avoirdupois]
av; avg: [average]
Avogadro constant: N_A; L
avoirdupois: avdp*
α: absorptance (thermal physiology); angular acceleration; thermal diffusivity (thermal physiology)
$[\alpha]^{20}_{D}$: optical rotation, specific

B: bel; [billion (10^9)]
B: [susceptance]
b: [bar]; barn; [bit]; [blood]
bacille Calmette-Guérin: BCG
BAL: 2,3-dimercapto-1-propanol (British antilewisite) Use chemical name
bal: [balance]
ballistocardiogram: BCG*
bar: No abbreviation (10^5 Pa)
barn: b (10^{-28} m^2)
basal body temperature: BBT*
basal metabolic rate: BMR*
basal metabolism: BM*
Baumé: Bé
BBB: [blood-brain barrier]
bbl: [barrel]
BBT: [basal body temperature]
bcc: [body-centered cubic]
BCD: [binary coded decimal]
BCG; B.C.G.: bacille Calmette-Guérin; [ballistocardiogram]
Bd; bd: [baud]
Bé: Baumé
beat per second: beat/s
bel: B
benzoyl: Bz

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

benzyl: Bzl
BeV; Bev: [billion electron volts]
Bhn: [Brinell hardness number]
Bi; bi: [biot]
billion: G (SI prefix, 10^9)
billion electron volts: GeV
biochemical oxygen demand: BOD*
bl: [blood]
blood: b* (respiratory physiology)
blood pressure: BP*
blood urea nitrogen: BUN*
BM; bm: [basal metabolism]
BMR: [basal metabolic rate]
BNF; B.N.F.: [British National Formulary]
board foot: See Table 2, Chapter 3
BOD: [biochemical oxygen demand]
body-centered cubic: bcc*
body temperature and pressure, saturated with water vapor: BTPS*
boiling point: bp
bovine serum albumin: BSA*
BP; B.P.; bp; b.p.: [blood pressure]; [boiling point]
B.P.; BP: [British Pharmacopoeia]
BPC; B.P.C.: [British Pharmaceutical Codex]
bpd: [barrel per day]
bps: [beat per second]; [bit per second]
Brinell hardness number: Bhn*
British antilewisite (2,3-dimercapto-1-propanol) Use chemical name
British National Formulary: BNF*; B.N.F.*
British Pharmaceutical Codex: BPC*; B.P.C.*
British Pharmacopoeia: B.P.*; BP*
British thermal unit: Btu* Convert to joule, J
bromsulphthalein: BSP*
BS: [blood sugar]; [British Standard]
B.S.: [British Standard]
b/s: [beat per second]; [bit per second]
BSA: [body surface area]; [bovine serum albumin]
BSP: [bromsulphthalein]
BTPS: [body temperature and pressure, saturated with water vapor]
BTU; Btu: [British thermal unit] Convert to joule, J
bu: [bushel]
BUN: [blood urea nitrogen]
BW: [bandwidth]
Bz: benzoyl
Bzl: benzyl

C: [Carboniferous (geology)]; Celsius; [centigrade]; coulomb (SI derived unit); [complement]; [curie]; [cytidine]
°C: degree Celsius
C1, C2, etc.: components of [complement]
C: capacitance
Ꞓ: [Cambrian (geology)]
c: [capillary]; [carat]; cent; centi (SI prefix, 10^{-2}); [*circa*]; [count]; [cubic]; [curie]; [cycle]
ca: [candle]; [candela]; [centare]; [*circa* (about)]
Cal: [kilocalorie]
cal: [calorie]
cal_{IT}: international steam table calorie
calcd: calculated
Calorie (1,000 calories): Cal Convert to joule, J
calorie: cal Convert to joule, J
Cambrian (geology): Ꞓ*

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

candela: cd (SI base unit)
candela steradian: cd·sr (SI name: lumen)
candle: Convert to candela, cd
candlepower: Use candela, cd
capacitance: C (in equations)
Carboniferous (geology): C*
carboxyhemoglobin: HbCO
carboxymyoglobin: MbCO
O-(carboxymethyl)cellulose: CM-cellulose*
cardiovascular system: CVS*
cb: [coulomb]
CBC: [complete blood count]
cc: [cubic centimeter]
CD: [circular dichroism]
cd: candela (SI base unit); [candle]
cdl: [candela]; [candle]
CDP: cytidine 5′-diphosphate
cd·sr: candela steradian (SI name: lumen)
CE: [chick embryo]
Celsius: C
cen: [centromere (genetics)]
cent: c (money; acoustics)
center of gravity: cg*
centi: c (SI prefix, 10^{-2}, as in centimeter, cm)
centigrade: Use Celsius, C
centimeter-gram-second: cgs (system of units)
centimeter per gram per second: $cm \cdot g^{-1} \cdot s^{-1}$
central nervous system: CNS*
centrifugation, speed and duration: *g*-min
centromere: cen*
cerebrospinal fluid: CSF*
CF: [complement fixation]
cf: [cubic foot]
cf.: *confer* (compare)
cfm: [cubic foot per minute] Convert to cubic meter per second, m^3/s
cfs: [cubic foot per second] Convert to cubic meter per second, m^3/s
CFT: [complement fixation test]
CG: [chorionic gonadotropin]
cg: [center of gravity]; centigram
cgs; c.g.s.: centimeter-gram-second (system of units); [centimeter per gram per second (viscosity)]
charge: Q
chemically pure: cp*
chick embryo: CE*
chorionic gonadotropin: CG*
chromosome, long arm of: q*
chromosome, short arm of: p*
Ci: [curie]
circa (about): ca.
circular dichroism: CD*
clo: [reciprocal of thermal conductance]
cm: centimeter; [cubic meter]
cm^2: square centimeter
cm^3: cubic centimeter
c/m: [count per minute]; [cycle per minute]
CMC; CM-cellulose: [*O*-(carboxymethyl)cellulose]
$cm \cdot g^{-1} \cdot sec^{-1}$: centimeter per gram per second
cmHg: centimeter of mercury Convert to newton per meter², N/m^2
cmil: [circular mil]
c/min: [count per minute]; [cycle per minute]
CMP: cytidine 5′-monophosphate
CNS: [central nervous system]
Co I; CoI: [coenzyme I]
Co II; CoII: [coenzyme II]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

CoA; Co A: coenzyme A
CoASAc: acetyl coenzyme A
CoASH: coenzyme A
coefficient: coef*
coenzyme I: nicotinamide adenine dinucleotide (NAD) or diphosphopyridine nucleotide (DPN) Do not use Co I
coenzyme II: nicotinamide adenine dinucleotide phosphate (NADP) or triphosphopyridine nucleotide (TPN) Do not use Co II
coenzyme A: CoA; Co A; CoASH
coenzyme A, acyl derivatives of: acyl-CoA
compare (*confer*, bring together): cf.
complement and its components: C, C1, C2, etc.*
complement fixation: CF*
complement fixation test: CFT*
complement of error function: erfc
concd, concn: concentrated, concentration
cond: [conductivity]; [conductor]
conductance: G
confer (bring together, compare): cf.
const: [constant]
continuous wave: cw*; CW*
cor: corrected (of melting points only)
cos: cosine
cosec: [cosecant]
cosecant: csc
cosh: hyperbolic cosine
cosine: cos
cot; cotan: [cotangent]
cotangent: cotan
coth: hyperbolic cotangent
coul: [coulomb]
coulomb: C (SI derived unit)
count per hour: count/h
count per minute: cpm; count/min
count per second: count/s
CP: [chemically pure]
cp: [candlepower]; [centipoise]; [chemically pure]
cph: [count per hour]
cpm: [count per minute]; [cycle per minute]
cps: [centipoise]; [count per second]; [cycle per second]
Cretaceous (geology): K*
c/s: [cycle per second]; [count per second]
csc: cosecant
csch: hyperbolic cosecant
CSF; csf: [cerebrospinal fluid]
ct: [cent (money, acoustics)]; [count]
CTP: cytidine 5′-triphosphate
cu: [cubic] Use exponent 3
cubic centimeter: cm^3
cubic decimeter: dm^3
cubic foot: See Table 2, Chapter 3
cubic inch: See Table 2, Chapter 3
cubic meter: m^3
cubic millimeter: mm^3
cubic yard: See Table 2, Chapter 3
cucm; cu cm: [cubic centimeter]
cuft; cu ft: [cubic foot]
cum; cu m: [cubic meter]
cumm; cu mm: [cubic millimeter]
curie: Ci (3.7×10^{10} s^{-1})
current: I (in equations)
cu yd: [cubic yard]
C.V.: [cultivar]; [cultivariant]
CVS; cvs: [cardiovascular system]
cw; CW: [continuous wave]
cwt: [hundredweight] Convert to kilogram, kg
cy: [cycle]
cycle per minute: cycle/min
cycle per second: cycle/s; in electricity, Hz

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

Cyd: [cytidine]
cy/m; cy/min: [cycle per minute]
Cys: cysteinyl
|
Cys, Cys: cystinyl
|
cy/s; cy/sec: [cycle per second]
cysteine residue: Cys
|
cystine residue: Cys; Cys
|
cytidine: Cyd; C (in combinations)
cytidine 5′-phosphates: CMP, CDP, CTP

D: [darcy]; debye; [Devonian (geology)]
D; D: [diffusion coefficient]
$D_{20,w}$: diffusion coefficient in water at 20°C
ᴅ: dextro configuration
2,4-D: [2,4-dichlorophenoxyacetic acid]
d: [day]; deci (SI prefix, 10^{-1}); [density]; [deoxy]; disintegration; [pennyweight]
d: dextrorotatory; density
da: [day]; deka (SI prefix, 10^1)
dAMP, dADP, dATP: deoxy AMP, ADP, ATP
daN: dekanewton
dansyl: DNS*
darcy: D*
dB; db: [decibel]
dbh: [diameter at breast height]
dc; d-c; DC: [direct coupled]; [direct current]
dCMP, dCDP, dCTP: deoxy CMP, CDP, CTP
DDT: [1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane]
DEAE-cellulose: [*O*-(diethylaminoethyl)cellulose]
debye: D
dec: [decomposition]; [decrease]
deci: d (SI prefix, 10^{-1}, as in decimeter, dm)
decibel: dB
decomposition (melting point): dec*
deg: [degree (arc, plane angle, temperature)]
degree: ° (plane angle)
degree Celsius: °C
degree Kelvin: Use K (without the degree sign)
degrees of freedom (statistics): df
deka: da (SI prefix, 10^1, as in dekagram, dag)
density: *d*; ρ (SI derived unit: kg/m^3)
deoxy: d (in nucleotides)
deoxyribonuclease: DNase
deoxyribonucleic acid: DNA
deoxyribosylthymine: dThd; dT (in combinations)
Devonian (geology): D*
dextro (in configurational sense): ᴅ
dextrorotatory: *d*
df; DF; *df*: [degrees of freedom (statistics)]
DFP: [diisopropylphosphofluoridate]
dGMP, dGDP, dGTP: deoxy GMP, GDP, GTP
diam: diameter
diameter at breast height: dbh*
dic: [dicentric (genetics)]
dicentric: dic*
2,4-dichlorophenoxyacetic acid: 2,4-D*
O-(diethylaminoethyl)cellulose: DEAE-cellulose*
diffusion coefficient: *D*
diisopropylphosphofluoridate: DFP*

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

dimethylaminonaphthalene-*S*-sulfonyl: DNS*
dIMP, dIDP, dITP: deoxy IMP, IDP, ITP
2,4-dinitrophenyl: DNP* (with trivial names); Dnp (with amino acid symbols)
diphosphopyridine nucleotide, oxidized form: DPN$^+$; NAD$^+$ preferred
diphosphopyridine nucleotide, reduced form: DPNH; NADH preferred
diphosphothiamine: DPT*
direct current: DC
dis: [disintegration]
disintegration per minute: dpm
disintegration per second: dps
dissociation constant, negative logarithm of: pK
dk: [deka]
d/m; d/min: [disintegration per minute]
DNA: deoxyribonucleic acid
DNase; DNAse; DNAase: [deoxyribonuclease]
DNP: [2,4-dinitrophenol]; [2,4-dinitrophenyl]
DNS: [dimethylaminonaphthalene-*S*-sulfonyl]
dol: [dollar]
doz: [dozen]
dpdt; DPDT: [double pole, double throw (electricity)]
dpm: disintegration per minute
DPN$^+$: diphosphopyridine nucleotide, oxidized form; NAD$^+$ preferred
DPNH: diphosphopyridine nucleotide, reduced form; NADH preferred
dps: disintegration per second
dpst; DPST: [double pole, single throw (electricity)]
DPT: [diphosphothiamine]
dr: [dram] See Table 2, Chapter 3
dThd: [deoxyribosylthymine]
dTMP, dTDP, dTTP: deoxy TMP, TDP, TTP
Dubois area: A_D*
dUMP, dUDP, dUTP: deoxy UMP, UDP, UTP
dwt: [pennyweight] Convert to gram, g
dy; dyn: [dyne]
dyne: dyn (10^{-5} N)
dψMP, dψDP, dψTP: deoxy ψMP, ψDP, ψTP

E: east; [erythrocyte]
E: electrode potential; energy; extinction
E_0: electrode potential, standard
E_0': standard electrode potential at constant pH
E: [expired gas]
e: base of natural logarithms
east: E
eastern equine encephalitis: EEE*
ECG: [electrocardiogram]
ED: [effective dose]; [error detection]
ED$_{50}$: [mean effective dose]
EDT: [electronic data processing]
EDTA: [ethylenediaminetetraacetic acid, or acetate]
EEE: [eastern equine encephalitis]
EEG: [electroencephalogram]
EFL: [effective focal length]
e.g.: *exempli gratia* (for example)
EKG: [electrocardiogram]
EKY: [electrokymogram]
EL: [elastic limit]; [electroluminescence]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

electrocardiogram: ECG*
electrode potential: *E* (see also E_0 and E_0')
electroencephalogram: EEG*
electrokymogram: EKY*
electromagnetic potential: emp
electromagnetic unit: emu
electromotive force: emf
electromyogram: EMG*
electron paramagnetic resonance: EPR*
electron spin resonance: ESR*
electron volt: eV
electroretinogram: ERG*
electrostatic unit: esu
emf: electromotive force
EMG: [electromyogram]
emp: electromagnetic potential
emu: electromagnetic unit
end: [endoreduplication (genetics)]
endoreduplication: end*
energy: *E*
entropy: *S*
EPR; epr: [electron paramagnetic resonance]
Eq; eq: [equation]; [equivalent]
equation: Eq.
equivalent: eq
erfc: complement of error function
ERG: [electroretinogram]
ERV: [expiratory reserve volume]
erythrocyte sedimentation rate: ESR*
ESR, esr: [electron spin resonance]; [erythrocyte sedimentation rate]
esu: electrostatic unit
et al.: *et alii* (and others)
etc.: *et cetera* (and so forth)
ethylenediaminetetraacetic acid or acetate: EDTA*
EUV: [extreme ultraviolet]
eV: electron volt
ev: [electron volt]
exempli gratia (for example): e.g.
exp: [experiment]; exponential
experiment: expt
experimental: exptl
expired gas: E* (respiratory physiology)
exponential: exp
expt: experiment
exptl: experimental
extinction: *E*
ϵ: molar extinction coefficient; permittivity
η: viscosity

F: [Fahrenheit]; farad (SI derived unit); [female]; [fermi]; filial generations (F_1, F_2, etc.)
F: luminous flux (in equations); variance ratio
f: [fathom]; femto (SI prefix, 10^{-15})
f.: *forma* (taxonomy)
f: [aperture ratio (optics)]; [focal length]; furanose (as suffix); [relative humidity]
FA: [fatty acid]
fa; fth; fthm: [fathom]
face-centered cubic: fcc*
FAD: flavin-adenine dinucleotide
$FADH_2$: flavin-adenine dinucleotide, reduced form
Fahrenheit: Use Celsius, C
farad: F (SI derived unit)
fathom: See Table 2, Chapter 3
fatty acid: FA*
fcc: [face-centered cubic]
FD: [focal distance]
fd: [farad]
FDNB: [1-fluoro-2,4-dinitrobenzene]
fdy: [faraday]
female: F; ♀

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

femto: f (SI prefix, 10^{-15}, as in femtometer, fm)
fermi: F*
FFC: [free from chlorine)
FFI: [free from infection]
FFU: [focus-forming units]
figure, figures: Fig., Figs.
filial generations: F_1, F_2, etc.
fL: [foot lambert]
flavin-adenine dinucleotide: FAD
flavin-adenine dinucleotide, reduced form: $FADH_2$
flavin mononucleotide: FMN
1-fluoro-2,4-dinitrobenzene: FDNB*
FM: frequency modulation
fm: [fathom]; femtometer; [from]
f Met: formylmethionyl
FMN: flavin mononucleotide
focal distance: FD*
focus-forming units: FFU*
follicle-stimulating hormone: FSH*
foot: See Table 2, Chapter 3
foot candle (10.76 lux): Use metric
for example: e.g. (*exempli gratia*)
forma: f. (taxonomy)
formylmethionyl: fMet
fp; FP; f.p.: [foot pound]; [freezing point]; [fusion point]
fps: [foot-pound-second (system of units)]; [foot per second]; [frame per second]
Fr: [franklin]
fr: [from]
Franklin structures: FS*
freezing point: fp
frequency: ν
frequency modulation: FM*
Fru: fructose residue
FS: [Franklin structures]; [frequency standard]
FSH: [follicle-stimulating hormone]
ft: [foot]
FTC: [fast time constant]
ft-c; ft-ca: [foot candle]
fth; fthm: [fathom]
ft-L, ft-lam: [foot lambert]
Fuc: fucose residue
fup: [fusion point]
furanose: *f* (as suffix)
fw: [fresh water]

G: [acceleration]; gauss; [geometric mean]; giga (SI prefix, 10^9); [glucose]; [guanosine]
G: [conductance]; [gravitational constant]
g; gm ; gr: [gram]
g (as superscript): grad; grade (plane angle)
g: unit of gravity or centrifugal force
Gal: galactosyl
gal: [gallon]
galactosamine: GalN
galactose residue: Gal
gallon: See Table 2, Chapter 3
GalN: galactosamine
GalNAc: *N*-acetylgalactosamine
galvanic skin response: GSR*
gamma: gamma ray, particle, or globulin; microgram (use μg); 10^{-5} oersted (magnetism)
gamma globulin: γ-globulin
gas constant: *R*
gas-liquid chromatography: GLC*
g-atom: gram-atom
gauss: G
Gb; gb: [gilbert]
gbs: [Gibbs unit (cryobiology)]
Gc: [gigacycle per second]
g cal; g-cal: [gram-calorie]
g-cm: gram-centimeter

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

GDP: guanosine 5′-diphosphate
gen. nov.: *genus novum* (new genus); in botany preferred to n.gen.
GFR: [glomerular filtration rate]
gfs·cm^{-2}: gram force second per square centimeter
GG: [gamma globulin]
Gi; gi: [gilbert]; [gill]
Gibbs unit: gbs*
giga: G (SI prefix, 10^9, as in gigahertz, GHz)
gilbert: Convert to ampere, A
gill: Convert to cubic meter, m^3
GLC: [gas-liquid chromatography]
Glc: [gas-liquid chromatography]; [glucose]
GlcA: gluconic acid
GlcN: glucosamine
GlcNAc: *N*-acetylglucosamine
GlcUA: glucuronic acid
Gln: glutaminyl
glomerular filtration rate: GFR*
Glu: glutamyl
Glu-6-P: glucose-6-phosphate
gluconic acid: GlcA
glucosamine: GlcN
glucose: Glc (residue); G (in some combinations); Glu (only in glucose phosphates)
glucose-6-phosphate: Glu-6-P; G-6-P
glucuronic acid: GlcUA
glutamic acid residue: Glu
glutamic acid or glutamine residue: Glx
glutamine residue: Gln
glutathione, oxidized: GSSG
glutathione, reduced: GSH
Glx: glutaminyl or glutamyl
Gly: glycyl
GMP: guanosine 5′-monophosphate
gm: [gram]
g-min: product of acceleration and time specifying speed and duration of centrifugation
g-mol; g mole: [gram molecule]
GMT: Greenwich mean time
G-6-P: glucose-6-phosphate
gpm: [gallon per minute]
gr: [grad, grade]; [gram]; [grain]
grad, grade: g (superscript)
gram: g
gram-atom: g-atom
gram-calorie: Convert to joule, J
gram-centimeter: g-cm
gram force second per square centimeter: gfs·cm^{-2}
gram molecule: g-mol
gravitational constant: *G* (in equations)
gravity, unit of acceleration of: *g*
greater than: >
Greenwich mean time: GMT
GSH: reduced form of glutathione
GSR: [galvanic skin response]
GSSG: oxidized form of glutathione
GTP: guanosine 5′-triphosphate
GTT: [glucose tolerance test]
guanosine: Guo; G (in combinations)
guanosine 5′-phosphates: GMP, GDP, GTP
Guo: [guanosine]
γ: gamma ray quantum; [microgram]; 10^{-5} oersted
γG; γ-globulin: [gamma globulin]

H: henry (SI derived unit)
H^{-1}: reciprocal henry
h: hecto (SI prefix, 10^2); hour
HA: [hemagglutination]
ha: [hectare]
HAI: [indirect hemagglutination]
HAU: [hemagglutination unit]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

Hb: hemoglobin
HbCO: carboxyhemoglobin
HbO_2: oxyhemoglobin
HCF: [highest common factor]
H chain: heavy chain
hcp: hexagonal close packed
Hct; HCT: [hematocrit]
HEAT: [human erythrocyte agglutination test]
heavy chain: H chain
hecto: h (SI prefix, 10^2, as in hectobar, hbar)
height: ht
hemagglutination: HA*
hemagglutination unit: HAU*
hemoglobin: Hb
hemolytic unit: HU*
henry: H (SI derived unit)
herpes simplex virus: HSV*
hertz: Hz (SI derived unit)
hexagonal close packed: hcp
hfs: hyperfine structure
hhd: [hogshead]
His: histidyl
histidine residue: His
HOP: [high oxygen pressure]
horsepower: Convert to watt, W
hour: h
HP: [harmonic progression]; [herpes virus]; [high pass]; [high power]; [high pressure]; [horsepower]
hp: [horsepower]
hr: [hour]
HSV: [herpes simplex virus]
ht: height
HU: [hemolytic unit]
hundredweight (100 or 112 pounds): Convert to kilogram, kg
HV: [high voltage]
hy: [henry]
hydrogen ion concentration, negative log of: pH
hydroxylysine residue: Hyl
hydroxyproline residue: Hyp
Hyl: hydroxylysyl
Hyp: hydroxyprolyl
hyperbolic trigonometric functions: sinh; cosh; tanh; coth; sech; csch
hyperfine structure: hfs*
Hz: hertz (SI derived unit)

I: [inosine]
I: current (in equations); intensity of radiation (in equations)
i: [isochromosome]
i.a.; ia: [intraarterial]
ibid.: *ibidem* (in the same place)
ic; i.c.: [intracerebral]; [intracutaneous]
ID: [infective dose]; [inside diameter]
ID_{50}: [mean infective dose]
id; i.d.: [inside diameter]; [intradermal]
id est (that is): i.e.
IDP: inosine 5′-diphosphate; [integrated data processing]
IE: [infrared emission]
i.e.: *id est* (that is)
IF; if: [intermediate frequency]
IH: [infectious hepatitis]
Ile: isoleucyl
im; i.m.: [intramuscular]; [infrared measurement]
immunizing unit: IU*
IMP: inosine 5′-monophosphate
in; in.: [inch]
inch: See Table 2, Chapter 3
inch of mercury: Convert to newton per meter^2, N/m^2
indirect hemagglutination: HAI*
infective dose: ID*

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

infrared: IR
INM: [international nautical mile] See Table 2, Chapter 3
inner diameter: ID
Ino: [inosine]
inorganic phosphate: P_i
inosine: Ino; I (in combinations)
inosine 5′-phosphates: IMP, IDP, ITP
in/s: [inch per second]; [interruption per second]
inside diameter: ID*
integrated data processing: IDP*
intensity of radiation: *I* (in equations)
international steam table calorie: cal_{IT}
international unit: IU
intraarterial: i.a.*
intracutaneous: i.c.*
intradermal: i.d.*
intramuscular: i.m.*
intraperitoneal: i.p.*
intravenous: i.v.*
inv: inversion (genetics)
i.p.; ip: [intraperitoneal]
ips: [inch per second]; [interruption per second]
IR; ir: [infrared]; [intelligence ratio]
ire; IRE: [infrared emission]
irm; IRM: [infrared measurement]
isochromosome: i*
isoleucine residue: Ile
ITP: inosine 5′-triphosphate
IU: [immunizing unit]; [international unit]
i.v.; iv: [intravenous]

J: joule (SI derived unit); [Jurassic (geology)]
joule: J (SI derived unit) (energy, including heat, work, nutrition)
joule per second: J/s (SI unit: *W*)
Jurassic (geology): J*

K: [Cretaceous (geology)]; kelvin (SI base unit)
K_a: acidic dissociation constant
K_m; K_M: [Michaelis constant]
k: [carat]; kilo (SI prefix, 10^3)
kcal: [kilogram-calorie]
kelvin: K (SI base unit)
kG: kilogauss (SI derived unit: T)
kg: kilogram (SI base unit)
kg-cal: [kilogram-calorie]
kg; kgf: [kilogram-force] Convert to newton, N
kgm: [kilogram mass]; [kilogram force meter]
kilo: k (SI prefix, 10^3, as in kilogram, kg)
kilobar: kbar Convert to newton per $meter^2$, N/m^2
kilocalorie: kcal; Cal Convert to joule, J
kilogram: kg (SI base unit)
kilogram-calorie: kcal (1,000 calories) Convert to joule, J
kilogram-force: kgf Convert to newton, N
kilohm: kΩ
kilojoule per degree Celsius: kJ/°C
kilopound force: Convert to newton, N
kiloroentgen: kR Convert to coulomb per kilogram, C/kg
kiloton: Convert to kilogram, kg
kJ/°C: kilojoule per degree Celsius
klb; klbf: [kilopound-force]
kn: [knot]
knot: See Table 2, Chapter 3
kohm: [kilohm]
kp: [kilopond]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

kR; kr: [kiloroentgen]
kΩ: kilohm

L: [lambert]; [liter]
L: Avogadro constant; inductance
L: levo configuration
l: [lambert]; [liter]; [lumen]; [lux]
l: levorotatory
Lac: lactose residue
lam: [lambert]
lambda: Use microliter
lambert: L Convert to candela per meter^2, cd/m^2
langley: ly Convert to joule per meter^2, J/m^2
large calorie: Convert to joule, J
lat.: latitude
lb: [pound] See Table 2, Chapter 3
LBF: [*Lactobacillus bulgaricus* factor]
lbf; lb: [pound-force] Convert to newton, N
lbm: [pound-mass] Convert to kilogram, kg
lbwt: [poundweight]
LC: [lethal concentration]
LCD: [least common denominator]
L chain: light chain
LCM: [least common multiple]
LD: [lethal dose]
LD$_{50}$: [mean lethal dose]
LD$_{\min}$: [minimum lethal dose]
LE: [lupus erythematosus]
least common denominator: LCD*
least common multiple: LCM*
lep: [lowest effective power]
less than: <
lethal concentration: LC*
lethal dose: LD*
Leu: leucyl
leucine residue: Leu
levo (in configurational sense): L
levorotatory: *l*
LH: [luteinizing hormone]
lh: [left hand]
li: [link]
light chain: L chain
lim: limit
liq: liquid
lit: [liter]
liter: No abbreviation, except l (in combinations); or convert to cubic decimeter, dm^3
lm: lumen (SI derived unit)
ln: logarithm, natural (base *e*)
loc. cit.: *loco citato* (in the place cited)
log: [logarithm]
logarithm: log (base 10 understood); ln (base *e*); log$_n$ (any base specified by *n*)
long.: longitude
long arm/short arm ratio (genetics): L/S*
longitude: long.
LPF: [leukocytosis promoting factor]
L/S: [long arm/short arm ratio (genetics)]
LSD: [lysergic acid diethylamide]
lu: [lumen]; [lux]
lumen: lm (SI derived unit)
luminous flux: *F* (in equations)
luteinizing hormone: LH*
lux: lx (SI derived unit)
lwm: [low water mark]
lx: lux (SI derived unit)
ly: [langley]
Lys: lysyl
lysergic acid diethylamide: LSD*
lysine residue: Lys
λ: symbol for wavelength (electromagnetism); [microliter]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

M: [male]; mega (SI prefix, 10^6); [metacentric chromosome]; [Mississippian (geology)]; 1,000 board feet (forestry); molar
M: [molar]; molecular weight
ᴍ: [molar]
m: meter (SI base unit); milli (SI prefix, 10^{-3}); [minute]; [mole]
m^2: square meter
m^3: cubic meter
m: mass; *meta*; [molal]
m (as superscript): minute (angular)
mA; ma: [milliampere]
mag: magnetic
magnetomotive force: mmf*
Mal: maltose residue
male: M; ♂
maltose residue: Mal
Man: mannose residue
mar: marker chromosome
mass: *m*
mat: [maternal]
max: maximum; maximal; [maxwell]
maxwell: Mx Convert to weber, Wb
Mb: myoglobin
MBC: [minimum bactericidal concentration]
MbCO: carboxymyoglobin
MbO_2: oxymyoglobin
md: [median]
$[M]^{20}_{D}$: molecular optical rotation
MDR: [minimum daily requirement]
Me: methyl
mean effective dose: ED_{50}*
mean infective dose: ID_{50}*
mean lethal dose: LD_{50}*
median effective dose: MED*
median infective dose: MID*
median lethal dose: MLD*
mega: M (SI prefix, 10^6, as in megacoulomb, MC)
megaton: Convert to kilogram, kg
melanocyte-stimulating hormone: MSH*
melting point: mp
melting temperature (DNA): T_m*
MEM: [minimal essential medium]
messenger ribonucleic acid: mRNA*
Met: methionyl
meta: *m*
metabolic quotient: Q
meter: m (SI base unit)
meter-lambert: m-L
meter per second: m/s (SI derived unit)
MetHb: methemoglobin
methionine residue: Met
methyl: Me
MFD: [minimum fatal dose]
mgd: [million gallons per day]
mg%: Substitute mg/100 ml, mg/100 mg, or mg/100 g, as appropriate
mho: reciprocal ohm (SI proposed name: siemens)
mi: [mile] See Table 2, Chapter 3
Michaelis constant: K_m
micro: μ (SI prefix, 10^{-6}, as in microcurie, μCi)
microhm: $\mu\Omega$
micromicro (prefix, 10^{-12}): Substitute pico, p
micromilli (prefix, 10^{-9}): Substitute nano, n
micron: Use 10^{-6} m or μm
MID: [median infective dose]
mil: 10^{-3} inch Convert to meter, m
mile: See Table 2, Chapter 3
mile, nautical: See Table 2, Chapter 3

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

mile per hour: mph Convert to meter per second, m/s; or to kilometer per hour, km/h

milli: m (SI prefix, 10^{-3}, as in millimeter, mm)

milligram percent: mg% Substitute mg/100 ml, mg/100 mg, or mg/100 g, as appropriate

millilambert: mL Convert to candela per meter^2, cd/m^2

millimicro (prefix, 10^{-9}): Substitute nano, n

millimicron: Substitute nanometer, nm

milliroentgen: mR Convert to coulomb per kilogram, C/kg

min: minimum; minute

minimum; minimal: min

minimum bactericidal concentration: MBC*

minimum lethal dose: LD$_{min}$*

minute: min

minute (arc): ′; m (superscript)

Mississippian (geology): M*

mixed melting point: mmp*

m-L: meter-lambert

MLD: [mean lethal dose]; [median lethal dose]; [minimum lethal dose]

mm: millimeter

mm^2: square millimeter

mm^3: cubic millimeter

mmf: [magnetomotive force]

mmp: [mixed melting point]

mo: month

mol: mole (SI basic unit: "quantity of substance")

molal: Substitute mol/kg

molar (mole per liter): M

molar extinction coefficient: ϵ

mole: mol (SI basic unit; "quantity of substance")

molecular optical rotation: $[M]_D^{20}$

molecular weight: mol wt; *M*

mol/kg: molal; mole per kilogram

month: mo

more than: >

mp; m.p.: [melting point]

MPD: [maximum permissible dose]; [minimum permissible dose]

MPE: [maximum permissible exposure]

mph: [mile per hour] Convert to meter per second, m/s; or to kilometer per hour, km/h

MR: [metabolic rate]

mRNA: [messenger ribonucleic acid]

m/s: meter per second (SI derived unit)

msd: [mean solar day]

MSH: [melanocyte-stimulating hormone]

msl; m.s.l.: [mean sea level]

MT; Mt: [megaton]

MW; M.W.: [molecular weight]

MWe; Mwe: [megawatt of electric power]

MW·h: megawatt-hour

Mx: [maxwell]

my (prefix): [myria]

my; m.y.: [million years]

myoglobin: Mb

myoglobin, carboxy: MbCO

myoglobin, oxy: MbO_2

myria (prefix, 10^4): Convert to kilo, k; or mega, M

mμ: [millimicron] Substitute nanometer, nm

mμg: Substitute nanogram, ng

mμm: Substitute nanometer, nm

μ: micro (SI prefix, 10^{-6}); [micron]; [micrometer]

μmeq: Substitute nanoequivalent, neq

μmg: Substitute nanogram, ng

μmm: Substitute nanometer, nm

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

μmsec: Substitute nanosecond, ns
μγ: Substitute picogram, pg
μμ: Substitute pico, p
μμc: Substitute picocurie, pCi
μμF; μμfd: Substitute picofarad, pF
μΩ: microhm

N: newton (SI derived unit); north; unspecified nucleoside; [normal]
N; N: [normal]
n: nano (SI prefix, 10^{-9}); neutron
n: refractive index; [number]
N_A: Avogadro constant
NA: [numerical aperture]
N.A.: [*Nomina Anatomica*]
nA; na: [nanoampere]
NAc: *N*-acetyl
N-acetylgalactosamine: GalNAc
N-acetylglucosamine: GlcNAc
NAD: nicotinamide adenine dinucleotide; [no appreciable disease]; [no appreciable difference]
NAD$^+$: nicotinamide adenine dinucleotide, oxidized form
NADH: nicotinamide adenine dinucleotide, reduced form
NADP$^+$: nicotinamide adenine dinucleotide phosphate, oxidized form
NADPH: nicotinamide adenine dinucleotide phosphate, reduced form
nano: n (SI prefix, 10^{-9}, as in nanowatt, nW)
α-naphthylthiourea: ANTU*
National Formulary: NF*
nautical mile: See Table 2, Chapter 3
ND; nd: [not determined]
NE: northeast
neper: Np*
neutron: n
new: [newton]
new genus: n.gen.; gen.nov. (*genus novum*) preferred in botany
new species: n.sp.; sp.nov. (*species nova*) preferred in botany
newton: N (SI derived unit)
newton per square meter: N/m^2 (proposed SI symbol: Pa)
new variety: n.var.; var.nov. (*varietas nova*) preferred in botany
N.F.: [National Formulary]
n.gen.: new genus; gen.nov. (*genus novum*) preferred in botany
n.sp.: new species; sp. nov. (*species nova*) preferred in botany
n.var.: new variety; var.nov. (*varietas nova*) preferred in botany
NI: [noise index]
nicotinamide adenine dinucleotide: NAD
nicotinamide adenine dinucleotide, oxidized form: NAD$^+$
nicotinamide adenine dinucleotide, reduced form: NADH
nicotinamide adenine dinucleotide phosphate, oxidized form: NADP$^+$
nicotinamide adenine dinucleotide phosphate, reduced form: NADPH
nicotinamide mononucleotide: NMN
Nir: ribosylnicotinamide residue
nm: nanometer; [nautical mile]; [nuclear magneton]
N/m^2: [newton per square meter]
nmi: [nautical mile]
NMN: nicotinamide mononucleotide
NMR; nmr: [nuclear magnetic resonance]
NNE: north northeast
NNW: north northwest

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

no.: *numero* (number)
nom.cons., nom.dub., nom.nud.; *nom. nov., nom.rej.*: all correct in the forms given
Nomina Anatomica: N.A.*
nonprotein nitrogen: NPN*
normal (concentration): N
normal temperature and pressure: NTP*
northeast: NE
north northeast: NNE
north northwest: NNW
northwest: NW
not determined: ND*
not significant: NS
NP: [nursing procedure]
Np: [neper]
NPN: [nonprotein nitrogen]
nRNA: [nuclear RNA]
NS; ns: [not significant]
NT; nt: [newton]
NTP; NTP: [normal temperature and pressure]
nuclear magnetic resonance: NMR
nuclear RNA: nRNA*
nucleoside, unspecified: N (*not* X)
number: no. (*numero*)
NW: northwest
ν: frequency

O: [Ordovician (geology)]
o: *ortho*
OAc: acetate
obs: observed
observed; observation: obs
OD; o.d.: [optical density]; [outside diameter]
Oe, Oer, oer: [oersted]
oersted: Oe Convert to ampere/meter, A/m
ohm: Ω (SI derived unit)
old tuberculin: OT*
op. cit.: *opere citato* (in the work cited)
opt: [optical]
optical density: OD (for suspensions); substitute absorbance (*A*) for solutions
optical rotation, molecular: $[M]_D^{20}$
optical rotation, specific: $[\alpha]_D^{20}$
optical rotatory dispersion: ORD*
ORD: [optical rotatory dispersion]
Ordovician (geology): O*
Orn: ornithyl
ornithine residue: Orn
ortho: *o*
orthophosphate: P_i
osM: osmolar
osmol: osmole
osmolal: osmol/kg
osmolar: osM
osmole: osmol
OT: [old tuberculin]
outside diameter: OD
ounce: See Table 2, Chapter 3
oxyhemoglobin: HbO_2
oxymyoglobin: MbO_2
oz: [ounce]
Ω: ohm (SI derived unit)
ω: angular velocity

P: [Permian (geology)]; [poise]; [pressure (respiratory physiology)]
ℙ: [Pennsylvanian (geology)]
P: [power]; pressure; probability; phosphate other than inorganic
p: phosphate other than inorganic; pico (SI prefix, 10^{-12}); [proton]; [chromosome, short arm of]
p: *para*; pressure (in equations); pyranose (as suffix)
PA: [power amplifier]
Pa: pascal (SI proposed unit)

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

PAB: [*p*-aminobenzoate]
PABA: [*p*-aminobenzoic acid]
para: *p*
paralytic dose: PD*
parsec: pc
partial specific volume: $\bar{v}$
parts per billion: ppb*
parts per million: ppm
PAS: [*p*-aminosalicylate]; [periodic acid-Schiff]
PASA: [*p*-aminosalicylic acid]
pascal: Pa (SI proposed unit)
PAT: [paroxysmal auricular tachycardia]
pat: [paternal (genetics)]
paternal: pat* (genetics)
PBI: [protein-bound iodine]
PC: [phosphocreatine]; [photocell]
pc: parsec
pC: [Precambrian (geology)]
PCA: [perchloric acid]
P-creatine: phosphocreatine
PD: potential difference; [paralytic dose]
pdl: [poundal]
pe: [probable error]
Pennsylvanian (geology): ℙ *
pennyweight: Convert to gram, g
P-enolpyruvate: phosphoenolpyruvate
PEP: [phosphoenolpyruvate]
percent: %
periodic acid-Schiff: PAS*
perm: Convert to kilogram/newton·second, kg/N·s
Permian (geology): P*
per mil; per mill; per mille: ‰
pfd: [picofarad]; [preferred]
PFU: [plaque-forming units]; [pock-forming units]
Ph: [phenyl]
pH: negative logarithm of hydrogen ion concentration
ph: [phot]
Phe: phenylalanyl
phenyl: Ph*
phenylalanine residue: Phe
phenylketonuria: PKU*
phosphate, inorganic: P_i
phosphate other than inorganic: *P*: *p*
phosphocreatine: *P*-creatine
phosphoenolpyruvate: *P*-enolpyruvate
P_i: inorganic phosphate (orthophosphate)
pico: p (SI prefix, 10^{-12}, as in picofarad, pF)
pint: See Table 2, Chapter 3
pion: π-meson
PK: [psychokinesis]
pK: negative logarithm of dissociation constant
PKU: [phenylketonuria]
PL: [plasma]
plaque-forming units: PFU*
plus or minus: ±
p.m.; P.M.; P.M.: *post meridiem* (after noon)
pmr; PMR: [proton magnetic resonance]
pock-forming units: PFU*
poise: P (10^{-1} Pa·s)
post meridiem (after noon): p.m., P.M., P.M.
potential difference: PD
pound: See Table 2, Chapter 3
poundal (13.825 kdyn): Use metric
pound per square inch: lb/in² or use metric (1 lb/in² = 703.1 kg/m²)
power: *P* (in equations)
ppb: [parts per billion]
pphm: [parts per hundred million]
PP_i: inorganic pyrophosphate

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

PPLO: [pleuropneumonia-like organism]
ppm.: parts per million
ppt: [parts per thousand]; ‰; [precipitate]
Precambrian (geology): pЄ
precipitate: ppt.
prepn: [preparation]
pressure: P; P* (respiratory physiology); p (in equations)
PRF: [pulse rate frequency]
Pro: prolyl
pro: [protein]
probability: P
proline residue: Pro
proton magnetic resonance: PMR*
pseudouridine: ψrd; ψ (in combinations)
pseudouridine 5′-phosphates: ψMP, ψDP, ψTP
psi: [pound per square inch]
PT: [physical therapy]
pt: [pint] See Table 2, Chapter 3
Puo: purine nucleoside, unspecified
PVP: [polyvinylpyrrolidone]
PVT: [pressure-volume-temperature]
Pyd: pyrimidine nucleoside, unspecified
pyranose: p (as suffix)
pyrophosphate, inorganic: PP_i
π-meson: pion
ψ: [ribosyluracil]
ψDP: pseudouridine 5′-diphosphate
ψMP: pseudouridine 5′-monophosphate
ψrd: [ribosyluracil]
ψTP: pseudouridine 5′-triphosphate

Q: [Quaternary (geology)]
Q_{10}: increase in rate of chemical reaction for each 10°C increase in temperature
Q: charge; quantity of heat, light, energy, electricity (in equations)
Q; q: [metabolic quotient]
q: [chromosome, long arm of]
QC: [quality control]
qr: [quire]
qt: [quart]
qual: qualitative
quant: quantitative
quantity of heat, light, energy, electricity: Q (in equations)
quart: See Table 2, Chapter 3
Quaternary (geology): Q*

R: roentgen; [Rankine]; [Réaumur]
R: resistance; gas constant
r: [roentgen]; [ring chromosome (genetics)]; [ribosyl]
r: radius; [relative humidity]
rad: absorbed dose of ionizing radiation (10^{-2} J/kg)(do not abbreviate); abbreviation for radian (SI supplementary unit, plane angular measure)
radian: rad
radio frequency: RF*
radius: r
rapid eye movements: REM*
rat unit: RU*
RBC: [red blood cells]
RBE; rbe: [relative biological effect]
rd: [rad]; [rod]
Re: [Reynolds number]
reactance: X
red blood cells: Substitute erythrocyte
refractive index: n; n_{D}^{20}
relative biological effect: RBE
relative humidity: RH*
REM: [rapid eye movements]
rem: roentgen equivalent man (rad × RBE)
replicative factor: RF*

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

RES: [reticuloendothelial system]
residual volume: RV*
resistance: R (in equations)
respiratory quotient: RQ*
retardation factor (chromatography): R_f
reticuloendothelial system: RES*
rev: [revolution]
revolution per minute, second: rpm, rps
Reynolds number: Re*
RF: [radio frequency]; [replicative factor]; [retardation factor]
R_f; R_F: [retardation factor (chromatography)]
rf: [radio frequency]; [reducing flame]
RH; rh: [relative humidity]
Rh: rhesus
rhe: measure of viscosity Convert to meter^2/newton·second, m^2/N·s
rhesus: Rh (blood factor)
Rib: ribosyl
riboflavin 5′-phosphate: FMN
ribonuclease: RNase
ribonucleic acid: RNA
ribose residue: Rib
ribosomal RNA: rRNA*
ribosyl (where needed): r
ribosylnicotinamide residue: Nir
ribosylthymine: Thd; T (in combinations)
ribosyluracil: ψrd; ψ (in combinations)
ring chromosome: r*
r/m: [revolution per minute]
rms: [root mean square]
RNA: ribonucleic acid
RNAse; RNase: [ribonuclease]
rod: See Table 2, Chapter 3
roentgen: R
roentgen equivalent man: rem*
root mean square: rms*
rpm: revolution per minute
rps: revolution per second
RQ: [respiratory quotient]
rRNA: [ribosomal RNA]
r/s: [revolution per second]
RU: [rat unit]
RV: [residual volume]; [rated voltage]
ρ: density

S: siemens (SI proposed unit); [Silurian (geology)]; south; Svedberg unit of sedimentation coefficient (10^{-13} second)
S: entropy (in equations)
s: second (SI base unit); [satellite (genetics)]; [stere]
s^{-1}: reciprocal second
s (as superscript): second (plane angle)
s: sedimentation coefficient
$s_{20,w}$: sedimentation coefficient corrected to water at 20°C
SA: [surface area]; [specific activity]
satellite: s* (genetics)
sc; s.c.: [subcutaneous]
scf: [standard cubic foot]
SD; SD: [standard deviation]
SE; SE: [standard error]; [southeast]
sec: secant; [second]
second: s (SI base unit)
sedimentation coefficient: s
Ser: seryl
serine residue: Ser
SH: sulfhydryl; [serum hepatitis]
sh: [shake (10^{-8} s)]
siemens: S (SI proposed unit)
Silurian (geology): S*
simian virus: SV*
sin: sine
Sm: [streptomycin]; [submetacentric chromosomes]
soluble RNA: Substitute tRNA
Sor: sorbose residue

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

south: S
southeast: SE
south southeast: SSE
south southwest: SSW
southwest: SW
specific activity: sp act
sp gr: specific gravity
sp. nov.: *species nova* (new species); in botany preferred to n.sp.
sq: square Use exponent 2
square centimeter: cm^2
square meter: m^2
square millimeter: mm^2
sr: steradian (solid angular measure)
sRNA: Substitute tRNA
SSE: south southeast
SSW: south southwest
St: [stoke]; [subtelocentric chromosomes]
st: [stere]
standard deviation: SD
standard error: SE
standard temperature and pressure, dry: STPD*
ster: [steradian]
steradian: sr (SI supplementary unit, solid angular measure)
stoke: St ($10^{-4}\ m^2 \cdot s^{-1}$)
STP; STP: standard temperature and pressure
STPD: [standard temperature and pressure, dry]
streptomycin: Sm*
subcutaneous: s.c.
Suc: sucrose residue
sulfhydryl: SH
surface area: SA*
susceptance: B*
SV: [simian virus]
Svedberg unit: S
SW: southwest
T: tera (SI prefix, 10^{12}); [Tertiary (geology)]; tesla (SI derived unit); [thymidine]; [ton]; [time]; [torr]; [ribosylthymine]
T: [temperature]; transmittance
t: [tonne (1,000 kg)]; [translocation (genetics)]
t: [ton (2000 or 2240 pounds)]
tan: tangent
TCA: [trichloroacetic acid]
TCID: [tissue culture infective dose]
TEAE-cellulose: [*O*-(triethylaminoethyl)cellulose]
TEL: [tetraethyl lead]
temp: temperature
temperature: temp; T (absolute, in equations)
temperature-sensitive: TS*
tera: T (SI prefix, 10^{12}, as in terameter, Tm)
Tertiary (geology): T*
tesla: T (SI derived unit)
Thd: [thymidine]; [ribosylthymine]
thin-layer chromatography: TLC*
thm: [therm]
Thr: threonyl
threonine residue: Thr
thymidine: dThd; dT (in combinations)
thymidine 5′-phosphates: dTMP, dTDP, dTTP
thyroid-stimulating hormone: TSH*
TLC: [thin-layer chromatography]; [total lung capacity]
T_m: [melting temperature]
TMV: [tobacco mosaic virus]
tobacco mosaic virus: TMV*
ton: See Table 2, Chapter 3
tonne: t (10^3 kg)
TPase: [tryptophanase]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

TPN^+: [triphosphopyridine nucleotide, oxidized form]
TPNH: [triphosphopyridine nucleotide, reduced form]
T_R: [Triassic (geology)]
tr: trace
transfer RNA: tRNA
translocation: t* (genetics)
transmittance: T
tri: [tricentric (genetics)]
Triassic (geology): T_R*
tricentric (genetics): tri*
trichloroacetic acid: TCA* Avoid if possible
1,1,1-trichloro-2,2-bis(*p*-chlorophenyl ethane): DDT*
O-(triethylaminoethyl)cellulose: TEAE-cellulose*
triphosphopyridine nucleotide, oxidized form: TPN^+; $NADP^+$ preferred
triphosphopyridine nucleotide, reduced form: TPNH; NADPH preferred
Tris; tris: [tris(hydroxymethyl)-aminomethane]
tris(hydroxymethyl)aminomethane: Tris*
tRNA: transfer RNA
Trp: tryptophyl
Try: [tryptophan, incorrect; or misprint for Tyr]
tryptophan residue: Trp
TS: [temperature-sensitive]
TSase: [tryptophan synthetase]
TSH: [thyroid-stimulating hormone]
TV: [tidal volume]
Tyr: tyrosyl
tyrosine residue: Tyr

U: uniformly labeled; unit; [uridine]
u: atomic mass unit (unified)
UDP: uridine 5′-diphosphate
UHF: ultrahigh frequency
ultraviolet: UV
UMP: uridine 5′-monophosphate
unc: uncorrected
uniformly labeled: U
unit: U
Urd: [uridine]
uridine: Urd; U (in combinations)
uridine 5′-phosphates: UMP, UDP, UTP
UT; ut: [universal time]
UTP: uridine 5′-triphosphate
UV; uv: [ultraviolet]

V: volt (SI derived unit); [volume]
V; v: [velocity]
v: [volt]; [venous (respiratory physiology)]
$\bar{v}$: partial specific volume
VA: volt ampere Use watts, W
Vac; vac: [volt (alternating current)]; [vacuum]
Val: valyl
valine residue: Val
vapor density: vd*
vapor pressure: vp*
var.: variety
variance ratio: F (statistics)
var.nov.: *varietas nova* (new variety); in botany preferred to n.var.
vc: [vital capacity]
vd: [vapor density]
Vdc; vdc: [volt (direct current)]
vel: [velocity]
velocity: v (SI derived unit: m/s)
venous: v* (respiratory physiology)
versus: vs.
VHF: very high frequency
VIA: [virus-inactivating agent]
viscosity: η
vol: volume

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

volt: V (SI derived unit)
volume: vol (SI derived unit: m^3)
vol/vol: volume ratio
vp: [vapor pressure]
vs.: *versus* (against)

W: watt (SI derived unit); west
W: work; [energy]; [weight]
w: [watt]
watt: W (SI derived unit)
watt-hour: W·h
wavelength: λ
WB: [wet bulb]
Wb: weber (SI derived unit)
WBC: [white blood cells]
WBGT: [wet bulb globe thermometer]
web: [weber]
weber: Wb (SI derived unit)
WEE: [western equine encephalitis]
week: wk
weight: wt
weight/volume: wt/vol
west: W
western equine encephalitis: WEE*
wet bulb: WB*
wet bulb globe thermometer: WBGT*
W·h: watt-hour
white blood cells: Use leukocytes
wk: week
work: *W* (in equations)
wt: weight
wt/vol: weight/volume
wt/wt: weight ratio

X: [xanthosine]; [reactance]
xanthosine: Xao; X (in combinations)
xanthosine 5′-phosphates: XMP, XDP, XTP
Xao: [xanthosine]
XDP: xanthosine 5′-diphosphate
XMP: xanthosine 5′-monophosphate
xtal: [crystal]
XTP: xanthosine 5′-triphosphate
Xyl: xylose residue

Y; *y*: [admittance]
yard: See Table 2, Chapter 3
yd: [yard]
year: yr
yr: year

Z: [zenith]
z: [atomic number]

[ ] Either spell out, or look for the spelled-out form for recommendation.
*Recommended abbreviation, but define at first mention.

13. Annotated Bibliography

INTRODUCTION

The bibliography presented here is extensive but not exhaustive. Lack of space prohibits the inclusion of many books that might be useful to writers and editors of biology papers. That a reference work does not appear in this list does not necessarily reflect against either its quality or its usefulness.

Some pertinent references not mentioned below are listed in Chapter 4 and some in the Literature Cited, which follows this bibliography.

STYLE MANUALS, GRAMMARS, WRITING AND PRINTING GUIDES

American Chemical Society. 1967. Handbook for authors. American Chemical Society Publications, Washington, D.C.

A guide for the author who plans to submit a manuscript to one of the journals published by the American Chemical Society. It covers the major aspects of manuscript preparation, including specified parts of the text, preferred use of terms, illustrations, presentation of data, and typing of final copy.

American Institute of Physics. 1967. Style manual. American Institute of Physics, New York, N.Y.

A guide for the author preparing an article for one of the journals published by the American Institute of Physics. It covers preparation of a scientific paper, general style, presentation of mathematical expressions, special characters and signs, preparation of illustrations, and a short history of a manuscript.

American Medical Association. 1971. Style book and editorial manual, 5th ed. Scientific Publications Division, American Medical Association, Chicago, Ill.

Especially applicable to journals of the AMA, but useful in preparation of manuscripts for other medical journals.

Arnold, E. C. 1963. Ink on paper. Harper & Row, New York, N.Y.

Well-illustrated account of printer's terms and equipment, typesetting, proofreading, layout, printing processes, paper, and binding.

Baker, S. 1966. The complete stylist. Thomas Y. Crowell Co., New York, N.Y.

Although *The Complete Stylist* was designed as a basic text and handbook for college students, it has sections that should be helpful to any biologist faced with writing or revising a paper. Among them are "The Research Paper," "A Writer's Grammar," and "A Glossary of Usage," all written with wit and sparkle. This book is more comprehensive than the writer's earlier book, *The Practical Stylist*. Professor Baker was a member of the committee that produced the first edition of the *Style Manual for Biological Journals*.

———. 1969. The practical stylist, rev. ed. Thomas Y. Crowell Co., New York, N.Y.

A new edition of a popular guide to writing, first published in 1962 as a paperback text for college students. Now in hard covers.

Barzun, J., and H. F. Graff. 1962. The modern researcher. Harcourt, Brace & World, New York, N.Y.

Excellent advice on pitfalls to watch for in library research.

Bernstein, T. M. 1965. The careful writer: a modern guide to English usage. Atheneum, New York, N.Y.

A discussion of language usage, good and bad; helpful to the manuscript editor as well as the writer.

Brown, R. W. 1954. Composition of scientific words. Published by the author, U.S. Geological Survey, Washington, D.C.

Compilation of Latin and Greek synonyms for English words; useful in coining new scientific terms. Valuable bibliography in etymology.

Collison, Robert L. 1969. Indexes and indexing: guide to the indexing of books and collections of books, periodicals, music, gramophone records, films, and other material, with a reference section and suggestions for further reading. Ernest Benn Limited, London.

A thorough study of indexing, with special emphasis on books but with a section devoted to the indexing of periodicals.

Cutler, A. G. 1970. Indexing methods and theory. Williams & Wilkins, Baltimore, Md.

This brief manual (only 51 pages) is the most practical guide available on the writing and preparation of indexes for publications in the life sciences. In concise, but explicit, fashion it provides instructions pertaining to preparation of copy for the printer, variation in index format, points of editorial style, procedures for assembling and collating index entries, and correction of index page proofs. Also, consideration is given to the perplexities of variations of nomenclature, overlapping fields of interest, and the ramifications of information peculiar to the life sciences.

Elsbee, L., and F. Bracher. 1967. Heath's college handbook of composition, 7th ed. D. C. Heath and Company, Boston.

A well-organized, well-indexed handbook on the fundamentals of composition.

Evans, B., and C. Evans. 1957. A dictionary of contemporary American usage. Random House, New York, N.Y.

A comprehensive guide to current English as spoken and written in the United States and England.

Follett, W. 1970. Modern American usage: a guide. Grosset and Dunlap, New York.

Very much like Fowler and Gowers' *Modern English Usage* but more permissive; highly recommended as a guide to desirable usage in American prose. "Edited and completed" by Jacques Barzun with the help of a small group of writers and teachers of English.

Fowler, H. W., and Sir Ernest Gowers. 1965. A dictionary of modern English usage, 2nd ed. Oxford University Press, New York, N.Y.

Detailed, precise, and often entertaining notes on prose style, grammar, and word meaning. Highly recommended.

Gowers, Sir Ernest. 1954. The complete plain words. Penguin Books, Baltimore, Md.

A reconstruction of the author's two previous books, *Plain Words* and *ABC of Plain Words*. It emphasizes "the choice and arrangement of words in such a way as to get an idea as exactly as possible out of one mind into another." As a paperback and as a guide to cogent writing, it should be within the reach of every scientist who aspires to publish.

Graves, R., and A. Hodge. 1961. The reader over your shoulder: a handbook for writers of English prose. Macmillan Co., New York, N.Y.

A historical review of the development of English prose style; a detailed exposition of the principles of clear statement and graceful writing; a ruthless dissection of faults in examples of many kinds of popular, political, journalistic, and literary writing.

Greenwood, J. A. 1969. Find it in Fowler: an alphabetical index to the second edition (1965) of H. W. Fowler's *Modern English Usage*: including, but not limited to, synonyms secerned, obsolete forms obelized, dubious usages dehorted, and catachreses condemned; supplemented by tables of American usages, Greek words and phrases, Irish and Scotish usages, and numeration; arranged for casual consultation or ready reference. Wolfhart Book Company, Princeton, N.J.

An exhaustive means for rapid access to words, terms of numeration, names, and authors discussed and cited in Fowler and Gowers (1965).

Hewitt, R. M. 1957. The physician-writer's book; . . . tricks of the trade of medical writing. W. B. Saunders Co., Philadelphia, Pa.

A wordy but thorough discussion of desirable and undesirable practices in the preparation of clinical and research reports.

King, L. S., and C. G. Roland. 1968. Scientific writing. American Medical Association, Chicago, Ill.

A series of essays representing the personal views of the authors on such diverse subjects as the parts of speech, the opening sentence, the outline, monotonous writing, and bloopers.

Knight, G. N., editor. 1969. Training in indexing. The M.I.T. Press, Cambridge, Mass.

A textbook delineating in minute detail the intricacies of indexing. It provides guide rules for the compilation of specialized

indexes and contains separate chapters on scientific, technical, and medical indexing. It specifies the categorization of subject matter, explains cross referencing and the classification of foreign words and phrases, notes common pitfalls and errors, and offers a method and a reason for each stage in the preparation of an index. Very valuable for beginners but also rich in suggestions for the advanced indexer, the editor, and the researcher.

Lambuth, D., and others. 1964. The golden book on writing. Viking Press, New York, N.Y.

A guide to prose style, with special attention to sentence structure, word usage, and punctuation. Less forceful than Strunk and White's *The Elements of Style* but equally useful. The book was produced in collaboration with K. A. Robinson, H. E. Joyce, W. B. Pressey, and A. A. Raven. It contains a useful chapter, "On Business Writing," by Walter O'Meara, author and former advertising executive, and a foreword by Budd Schulberg.

Lasky, J. 1954. Proofreading and copy-preparation: a textbook for the graphic arts industry. Mentor Press, New York, N.Y.

A very detailed manual on the practices of proofreading and copy editing, with sections on indexing, compounding of English words, punctuation, capitalization, use of italics, syllabification, abbreviations and contractions, homonyms, and typography.

McCartney, E. S. 1953. Recurrent maladies in scholarly writing. University of Michigan Press, Ann Arbor.

Essays on writing and editing that are informative as well as entertaining.

Menzel, D. H., H. M. Jones, and L. G. Boyd. 1961. Writing a technical paper. McGraw-Hill Book Co., New York, N.Y.

A practical, well-organized guide for improving grammar and style in the preparation of technical articles. The authors discuss some of the common flaws in technical exposition, try to explain how they interfere with smooth communication, and describe basic methods of correcting them.

Miles, S. R. 1957. How to make tables of information. Purdue University Agricultural Experiment Station, Lafayette, Ind.

A small book containing detailed instructions for making tables. It shows many examples of tables properly constructed.

Mitchell, J. H. 1968. Writing for professional and technical journals. John Wiley & Sons, New York, N.Y.

Writing techniques common to all scientific articles are discussed in the first four chapters, techniques for specific disciplines and journals in the fifth.

Nicholson, M. 1957. A dictionary of American-English usage. Oxford University Press, New York, N.Y.

An adaptation of H. W. Fowler's celebrated work—American variations. It retains many of the words and much of the flavor of the original. A complete and unabridged reprint is available as a paperback Signet Book, published by the New American Library, New York, N.Y.

Perrin, P. G. 1968. Writer's guide and index to English, 4th ed. Scott, Foresman and Co., Glenview, Ill.

The first part of this textbook contains chapters on stages in writing and on methods of developing sentences, paragraphs, and various types of papers. A section on revising begins with the statement "Most good writing is rewritten writing" and includes chapters on revising sentences, phrases, and punctuation. The second part, or index to English, is a series of comments or short discussions on alphabetically arranged items: words and constructions, grammar, and language facts.

Skillin, M. E., R. M. Gay, and other authorities. 1964. Words into type: a guide in the preparation of manuscripts; for writers, editors, proofreaders, and printers, rev. ed. Appleton-Century-Crofts, New York, N.Y.

A detailed guide to preparation of manuscripts, preparation of copy, correction of proof, typography and illustrations, style conventions, grammar, and word usage. Highly recommended. Excellent index.

Strunk, W., Jr., and E. B. White. 1959. The elements of style. Macmillan Co., New York, N.Y.

A highly recommended exposition on attaining a graceful, clear writing style. Though the coverage is brief (only 71 pages), the advice offered is practical and excellent.

Trelease, S. F. 1969. How to write scientific and technical papers. M.I.T. Press, Cambridge, Mass.

A profound, but concise, treatment of the logical considerations in scientific writing. Highly recommended as the most scientific of the many books on this subject.

Turabian, K. L. 1967. A manual for writers of term papers, theses, and dissertations. 3rd ed., rev. University of Chicago Press, Chicago, Ill.

Although this small book was designed for university students, it contains much information of value to research scientists writing for publication.

Turner, R. P. 1964. Grammar review for technical writers. Holt, Rinehart and Winston, New York, N.Y.

The author of this simply written, well-organized 118-page book discusses the parts of speech and gives numerous examples in words familiar to scientists. In one chapter he discusses sentence structure and in another punctuation.

UNESCO. 1968. Guide for the preparation of scientific papers for publication. SC/MD/5. United Nations Educational, Scientific, and Cultural Organization, Paris, France.

Only six pages long, this guide contains explicit recommendations for a code of good practice in the preparation and submission of manuscripts and abstracts. The code has been widely circulated internationally among authors and editors as a means of encouraging uniform standards in scientific publication.

United States Government Printing Office. 1967. Style manual, revised edition. United States Government Printing Office, Washington, D.C.

A very comprehensive authority that supplies guidance not readily found elsewhere. Especially helpful on alphabets, abbreviations, and syllabification in foreign languages; formation of compound words; capitalization.

University of Chicago Press. 1969. A manual of style, 12th edition, revised. University of Chicago Press, Chicago, Ill.

An excellent standard for authors, editors, and proofreaders. This new edition not only provides clear and simple guidelines for preparing and editing copy, but also gives welcome attention to the technicalities of preparing such copy for scientific publication. Highly recommended.

Woodford, F. P., editor. 1968. Scientific writing for graduate students. Rockefeller University Press, New York, N.Y.

Offers a logical scheme for organizing and writing research reports for publication in scientific journals. Highly recommended.

Zweifel, F. W. 1961. A handbook of biological illustration. Phoenix Science Series, University of Chicago Press, Chicago, Ill.

A very useful guide for artists, authors, and editors on how to prepare illustrative materials of various kinds for inclusion in scientific publications.

DICTIONARIES AND SOURCE BOOKS

Berrey, L. V., and G. Carruth, editors. 1962. Roget's international thesaurus, 3rd ed. Thomas Y. Crowell Co., New York, N.Y.

The classic reference book of synonyms, with words grouped according to ideas rather than alphabetically as in a dictionary.

Betteridge, H. T. 1965. The new Cassell's German dictionary. Funk and Wagnalls Co., New York, N.Y.

A two-part dictionary with German words translated into English in the first part and English words with German equivalents in the second part.

Blake, J. B., and C. Roos, editors. 1967. Medical reference works 1679–1966. Medical Library Association, Chicago, Ill.

A thorough, annotated list of dictionaries, indexes, bibliographies, directories, reviews, histories, and other sources for the writer and researcher in clinical and investigative medicine.

Crowley, E. T., and R. C. Thomas, editors. 1970. Acronyms and initialisms dictionary, 3rd ed. Gale Research Company, Detroit, Mich.

Nonscientific, as well as scientific, entries. An excellent source for explanations of otherwise hard-to-identify abbreviations.

Dorland's Illustrated Medical Dictionary, 24th ed. 1965. W. B. Saunders Co., Philadelphia, Pa.

One of the standard medical dictionaries that has gone through many editions.

Gillispie, C. C., editor in chief. 1970. Dictionary of scientific biography. 2 vols. Charles Scribner's Sons, New York, N.Y.

A definitive multivolumed encyclopedia covering men in biology and medical science, chemistry, mathematics, astronomy, physics, and the earth sciences from classical antiquity to modern times. Emphasis in entries is on scientific accomplishments and careers rather than chronological details. Short bibliographies of primary and secondary sources. The third and fourth volumes are scheduled for publication in 1971.

Girard, D. 1968. The new Cassell's French dictionary. Funk and Wagnalls Co., New York, N.Y.

A two-part dictionary with French words translated into English in Part I, and English words with French equivalents in Part II.

Gordon, B. L., editor. 1971. Current medical information and terminology, 4th ed. American Medical Association, Chicago, Ill.

Standard American terms, with synonyms, for diseases and syndromes. Each disease is briefly defined and described. Multilingually cross-referenced. Abbreviations, symbols, glossary.

Gray, P. 1957. The dictionary of the biological sciences. Reinhold Publishing Co., New York, N.Y.

Not exhaustive in coverage but handy for confirmation of spelling of many scientific terms and names.

Hinsie, L. E., and R. J. Campbell. 1970. Psychiatric dictionary, 4th ed. Oxford University Press, New York, N.Y.

Extended explanatory definitions of terms from psychiatry, psychology, and neurology; pertinent selected terms from general medicine. Some definitions include bibliographic references. Biographical entries include name, birth and death years, and brief identification.

Institute of Laboratory Animal Resources, National Research Council. 1971. Animals for research: a directory of sources of laboratory animals, fluids, tissues, organs, 8th edition revised. National Academy of Sciences, Washington, D.C.

Lists of domestic and nature-obtained animals used in biological research: chickens, turkeys, rabbits, mice, rats, hamsters, gerbils, guinea pigs, dogs, cats, cattle, swine, horses, ponies and lower animals (chordates through protozoans). Common and scientific names, stock and strain terms and abbreviations, names and addresses of suppliers (and their abbreviations). A convenient, inexpensive source for confirmation of spellings of animal names and symbols.

Jaeger, E. C. 1955. A source-book of biological names and terms, 3rd ed. Charles C Thomas, Springfield, Ill.

Good general reference book for etymology of almost 14,000 biological terms. Introduction contains transliterations from Greek to Latin and rules for Greek prefixes and Latin declensions.

Jenkins, F. B. 1969. Science reference sources, 5th ed. M.I.T. Press, Cambridge, Mass.

An excellent guide to science reference materials arranged by major disciplines or fields, which are further subdivided; the

biological sciences are subdivided into general biology, botany, zoology, and biochemistry and biophysics. Within the subdivisions the entries are alphabetically arranged under type of reference work, such as bibliography, dictionary, handbook.

Leader, R. W., and I. Leader. 1971. Dictionary of comparative pathology and experimental biology. W. B. Saunders Co., Philadelphia, Pa.

A valuable supplement to older dictionaries of biology or medicine, containing many newer terms from both fields. Useful tables of animal parasites, animal blood values, experimental antibiotics, animal and virus classification, and chromosome complements. Full names and addresses of many societies and associations in biology, and veterinary and human medical sciences.

Marler, E. E. J. 1967. Pharmacological and chemical synonyms: a collection of names of drugs and other compounds drawn from the medical literature of the world. Excerpta Medica Foundation, New York, N.Y.

Chemical, generic, code, and trade names; international scope.

Peers, E. A., J. V. Barragan, F. A. Vinyals, and J. A. More, editors. 1960. Cassell's Spanish dictionary. Funk and Wagnalls Co., New York, N.Y.

The first part of this equally divided dictionary consists of Spanish words and their English equivalents; the second part contains the English terms and their corresponding Spanish equivalents.

Rebora, P. 1964. Cassell's Italian dictionary. Funk and Wagnalls Co., New York, N.Y.

Equally divided into two parts, the first half consisting of Italian words translated into English and the latter half of English words and their Italian equivalents.

Rieger, R., A. Michaelis, and M. M. Green, editors. 1968. A glossary of genetics and cytogenetics: classical and molecular, 3rd ed. Springer-Verlag New York, New York, N.Y.

A more extensive selection of terms than will be found in dictionaries of biology or medicine; definitions, explanations, diagrammatic illustrations, and source references to primary and secondary literature. Includes biochemical genetics.

Simpson, D. P. 1960. Cassell's new Latin dictionary. Funk and Wagnalls Co., New York, N.Y.

Two-thirds of this dictionary consists of Latin words and their English equivalents; the remaining third is devoted to the conversion of English words to classical Latin.

Sliosberg, A. 1964. Elsevier's medical dictionary (in five languages: English/American, French, Italian, Spanish, and German). Elsevier Publishing Co., New York, N.Y.

This multilingual dictionary is divided into two sections—the first comprises the English/American terms with their equivalents in the other four languages, and the second section consists of indexes in the other languages, each referring back to the numbered entries in the first part.

Smirnitsky, A. I., editor. 1967. Russian-English dictionary, 7th ed. E. P. Dutton and Co., New York, N.Y.

Good up-to-date general dictionary that should be used in conjunction with the *English-Russian Dictionary,* 7th ed., edited by V. K. Muller and published in 1959 by E. P. Dutton and Co., New York, N.Y.

Stedman's Medical Dictionary, 21st ed. 1966. Williams & Wilkins Co., Baltimore, Md.

One of the highly respected American medical dictionaries.

Stern, W. T. 1966. Botanical Latin. Hafner Publishing Co., New York, N.Y.

A useful working guide to the Latin internationally used by botanists for the description and naming of plants. It includes vocabulary, abbreviations, and grammar, as well as the history of botanical Latin.

USAN Council. 1967; 1971. United States adopted names: 1961–1966 cumulative list; 1967–1970 cumulative list. U.S. Pharmacopeia, Rockville, Md.

Chemical, generic, and trade names; code numbers; uses; molecular and structural formulas for drugs and related products.

Webster's New International Dictionary of the English Language, Second Edition, Unabridged. 1935. G. & C. Merriam Co., Springfield, Mass.

Valuable for its attempt to define the standing of English words (whether bookish, colloquial, or substandard) and to suggest whether usages are proper or improper.

Webster's Third New International Dictionary of the English Language, Unabridged. 1961. G. & C. Merriam Co., Springfield, Mass.

The standard American dictionary for spelling and meaning of English words. It is excellent for definitions of scientific terms and extremely valuable in providing the scientific equivalents for the common names of organisms.

Webster's Seventh New Collegiate Dictionary. 1963. G. & C. Merriam Co., Springfield, Mass.

An excellent desk dictionary for author or editor. It is based on the unabridged *Webster's Third New International Dictionary*. For syllabication of words, it is preferable to the unabridged dictionary, from which it sometimes differs as a result of later thinking by the editors on the principles of word division.

Wilson, C. O., and T. E. Jones. (Annual publication.) American drug index. J. B. Lippincott, Philadelphia, Pa.

Dictionary of drugs available from American producers: generic and trade names, dosage forms, uses. Names and addresses of pharmaceutical manufacturers.

INDEXES AND PERIODICAL LISTS

Biological Abstracts. (Annual publication.) Biological Abstracts list of serials with title abbreviations. Biological Abstracts, Philadelphia, Pa.

An alphabetical listing of complete serial titles and their abbreviations. Publications in the list are those contributing to *Biological Abstracts.*

Chemical Abstracts Service. 1969. ACCESS: key to the source literature of the chemical sciences. American Chemical Society, Washington, D.C.

An alphabetical listing of journal title abbreviations. Provides reference to a former title, if there was one, language of publication, publication history showing volume and issue numbers and date, address of publisher, current price, and other information. Serial and nonserial publications are listed.

Chicorel, M., editor. 1967. Ulrich's international periodicals directory, 12th ed. R. R. Bowker Co., New York, N.Y.

A classified guide to a selected list of current periodicals, foreign and domestic. For each citation it gives title and subtitle, language of text, year first published, frequency of publication,

price, editor, publisher, subscription address, cumulations and indexes, circulation, and where abstracted or indexed.

Fleurent, C. H. A. 1961. World medical periodicals, 3rd ed. (Also 1968 Supplement to the third edition.) World Medical Association, New York, N.Y.

Titles, addresses of publishers, and title abbreviations based on the rules of *World List of Scientific Periodicals.*

Titus, E. B., editor. 1965. Union list of serials in libraries of the United States and Canada, 3rd ed. 5 vols. H. W. Wilson Co., New York, N.Y.

An alphabetical listing of serial publications in North America; 156,449 entries and cross references.

Williams, P. C., compiler. 1968. Abbreviated titles of biological journals, 3rd ed. The Biological Council, Institute of Biology, London, England.

Titles and their abbreviations, selected from *World List of Scientific Periodicals.* Not recommended for American publications but a useful source for checking proofs of articles being published in British journals.

STANDARDS AND CODES

American National Standards Institute. 1969. American national standard for the abbreviation of titles of periodicals. ANSI Z39.5. American National Standards Institute, New York, N.Y.

A guide for abbreviating the titles of both serial and nonserial publications. The detailed recommendations are intended for authors, editors, and librarians in preparing unambiguous abbreviations for the titles of publications cited in bibliographies, references, and footnotes.

American Standards Association. 1959. American standard illustrations for publication and projection. ASA Y15.1-1959. American Society of Mechanical Engineers, New York, N.Y.

A small booklet (only 10 pages of explanation and illustrations) on the planning and drafting of diagrams and graphs that can be used for either publication or projection.

ASTM Committee on Metric Practice. 1970. Standard metric practice guide: a guide to the use of SI—the International

System of Units. ASTM 380-70. American Society for Testing Materials, Philadelphia, Pa.

A concise, detailed handbook on the units and symbols of the International System of Units (Système International d'Unités), the modernized metric system, including the base units, supplementary units, derived units, and multiple and submultiple units. Specifies rules for SI usage and style (capitalization, plurals, punctuation, number grouping, equations, and derived units), and for conversion, rounding, and establishing significant digits. Appendix A1 defines related nontechnical terms; Appendix A2 describes the historical and rational basis for SI; Appendix A3 provides conversion factors for units, listed alphabetically and by class of unit.

Chisholm, L. J. 1967. Units of weight and measure: international (metric) and U.S. customary. National Bureau of Standards Miscellaneous Publication 286. U.S. Government Printing Office, Washington, D.C.

A short history of the metric system; definitions, spelling, and symbols for units; factors for conversion to and from U.S. customary and metric units; lengthy computer-printout tables for conversion of the major units of length, mass, volume, and area.

Dybkaer, R., and K. Jorgensen. 1967. Quantities and units in clinical chemistry. Williams & Wilkins Co., Baltimore, Md.

Descriptions of quantities, units, and abbreviations pertinent to clinical chemistry, clinical physiology, clinical serology, and hematology. Based on SI.

Hemming, F., editor. 1958. Official list of family-group names in zoology; first instalment: names 1–236. International Trust for Zoological Nomenclature, London, England.

A list of 236 family-group names officially approved by the International Commission on Zoological Nomenclature. The following information is provided for each family name: name of author, date and place of publication, and "type genus."

International Anatomical Nomenclature Committee. 1968. *Nomina anatomica*, 3rd ed. Excerpta Medica Foundation, New York, N.Y.

Latin names in human anatomy for bones; ligaments, articulations, and joints; muscles; viscera; vessels; nerves; sensory organs; integument; and body regions. The alphabetical index is very helpful in finding specific terms.

———. 1970. *Nomina embryologica.* Federation of American Societies for Experimental Biology, Bethesda, Md.

An attempt to do for embryology what *Nomina anatomica* does for anatomy. Latin terms and their English equivalents are grouped in various categories, including reproduction, meiosis, histogenesis, skeletal system, lymphatic system, eye, and ear.

International Committee on Nomenclature of Bacteriology. 1966. International code of nomenclature of bacteria. Int. J. Syst. Bacteriol. 16(4):459–490.

Describes the principles upon which bacterial nomenclature is established. Provides rules and recommendations for naming of taxa, designation of nomenclatural types, publication of names, citation of authors and names, changes in names, rejection and replacement of names, and orthography and gender of names and epithets.

International Committee on Veterinary Anatomical Nomenclature. 1968. *Nomina anatomica veterinaria.* World Association of Veterinary Anatomists, Vienna, Austria.

Latin names in animal anatomy for bones; ligaments, articulations, and joints; muscles; viscera; vessels; nerves; sensory organs; integument; and body regions. The absence of an index makes it somewhat difficult to locate specific terms quickly.

International Organization for Standardization (ISO). 1969. Rules for the use of units of the International System of Units and a selection of the decimal multiples and submultiples of the SI Units. ISO Recommendation R 1000-1969(E). USA Standards Institute (now American National Standards Institute), New York, N.Y.

Tables of the SI base units and derived units, their symbols, the prefixes for multiples and submultiples of units, and rules for their use. Not as comprehensive as the ASTM *Standard Metric Practice Guide* (1970).

International Union of Biochemistry. 1965. Enzyme nomenclature. Elsevier Publishing Co., New York, N.Y.

Recommended symbols for enzyme kinetics; classification and recommended nomenclature for enzymes; table of classification numbers, and systematic and trivial names for enzymes, with characteristic chemical reactions. Detailed indexes and bibliographies.

IUPAC Commission on Symbols, Terminology, and Units. 1968. Draft of an extensively revised version of the 1959 "Manual of Physicochemical Symbols and Terminology." IUPAC Information Bull. 32.

Symbols, terminology, and units in chemistry, physics, and engineering tentatively agreed upon by a commission of the International Union of Pure and Applied Chemistry.

Lanjouw, J., chairman, and F. A. Stafleu, secretary, Editorial Committee. 1966. International code of botanical nomenclature. Kemink en Zoon, Utrecht, Netherlands.

Provides the principles that form the basis of the system of botanical nomenclature. Establishes rules for putting the nomenclature of the past into order, and providing for that of the future, with recommendations for bringing about greater uniformity and clarity.

Percy, C. L., J. W. Berg, and L. B. Thomas, editors. 1968. Manual of tumor nomenclature and coding. American Cancer Society, New York, N.Y.

A guide to standard terminology in pathology and oncology.

Schenck, E. T., and J. H. McMasters. 1956. Procedure in taxonomy, 3rd ed. Stanford University Press, Stanford, Calif.

A thorough presentation of the essential features of zoological nomenclature.

Stoll, N. R., chairman, and R. V. Melville, secretary, Editorial Committee, International Commission on Zoological Nomenclature. 1961. International code of zoological nomenclature. International Trust for Zoological Nomenclature, London, England.

Establishes a set of criteria to be met in giving an animal a scientific name, with its proper reference to author and date; also establishes criteria for regulating names given in the past.

United States of America Standards Institute. 1967. USA standard for periodicals: format and arrangement. Z39.1. United States of America Standards Institute (now American National Standards Institute), New York, N.Y.

Recommendations intended to guide and assist editors and publishers in organizing the bibliographic information appearing in their periodicals so that the publications cited can be readily identified and used.

United States of America Standards Institute. 1968. USA standard basic criteria for indexes. Z39.4. United States of America Standards Institute (now American National Standards Institute), New York, N.Y.

Guidelines and a uniform vocabulary for use in the preparation and evaluation of indexes.

U.S. Department of Health, Education, and Welfare. 1967. Eighth revision international classification of diseases, adapted for use in the United States. Public Health Service Publication 1693. U.S. Government Printing Office, Washington, D.C.

Terms based on those of *International Statistical Classification of Diseases,* with adaptations to facilitate hospital indexing of cases.

Vilmorin, R. de, chairman. 1961. International code of nomenclature for cultivated plants. Regnum Vegetabile, vol. 22.

Widely accepted publication produced by the Editorial Committee of the International Commission for the Nomenclature of Cultivated Plants (International Union of Biological Sciences), which formulated and adopted the code. The preface contains a summary of changes made since the 1958 edition was published.

World Health Organization. 1967. Manual of the international statistical classification of diseases, injuries, and causes of death. World Health Organization, Paris, France.

Standard terms used in epidemiology and vital statistics; based on recommendations of the Eighth Revision Conference, 1965, and adopted by the Nineteenth World Health Assembly.

HANDBOOKS

Altman, P. L., and D. S. Dittmer, editors. 1964. Biology data book. Federation of American Societies for Experimental Biology, Washington, D.C.

Broad scope, but limited coverage; tabulations of quantitative and qualitative data on genetics and cytology, reproduction, development and growth, morphology, nutrition and digestion, metabolism, respiration and circulation, blood, biological regulators and toxins, biophysical and biochemical characteristics, environment and survival, parasitism, and materials and methods. Covers the more common animals and plants.

Crow, W. B. 1964. A synopsis of biology, 2nd ed. Williams & Wilkins Co., Baltimore, Md.

A narrative summary of the whole of biology with emphasis on the more elementary data; divided into the following sections: form and structure (morphology), functions (physiology), organism and environment (ecology), evolution and heredity (genetics), plant classification (systematic botany), animal classification (systematic zoology), applications of biology (applied biology), and the technique of biology (biotechnology).

Dayhoff, M. O., editor. 1969. Atlas of protein sequence and structure, 4th ed. National Biomedical Research Foundation, Silver Spring, Md.

An atlas divided into three parts covering the known protein and nucleic acid sequences. Approximately one-third of the book is devoted to a narrative discussion of biochemical evolution and phylogenetic trees, another third to amino acid sequences produced directly from sequence information in the genetic material, and the remaining third to foldouts of the three-dimensional structure of lysozyme, protein alignments, and transfer RNA alignments.

Diem, K., and C. Lentner, editors. 1968. Documenta Geigy: Wissenschaftliche Tabellen, 7th ed. J. R. Geigy S.A., Basel, Switzerland.

Tables of information on mathematics and statistics, physics, physical chemistry, biochemistry, nutrients, body composition and function, body fluids, body measurements, hormones, and international biological standards and preparation references. (In German.)

Gray, D. E., editor. 1957. American Institute of Physics handbook. McGraw-Hill Book Co., New York, N.Y.

Tables of quantitative data on mechanics, acoustics, heat, electricity and magnetism, optics, atomic and molecular physics, and nuclear physics. Much descriptive information is included in the form of concepts, definitions, nomenclature, standards, and other explanatory material.

Long, C., editor. 1961. Biochemists' handbook. Van Nostrand-Reinhold Co., New York, N.Y.

A presentation in concise form of factual biochemical information. Many of the data are quantitative and given in the form of tables; some, however, are mainly qualitative and are given as text. The six main sections of the book deal with chemical data, data on individual enzymes, metabolic pathways, chemical composition of animal tissues and body fluids, chemical composition of plant tissues, and physiological and nutritional data.

Sober, H. A., editor. 1970. Handbook of biochemistry. Chemical Rubber Co., Cleveland, Ohio.

Tabulations of selected data for molecular biology covering amino acids; peptides and proteins; carbohydrates; lipids; steroids; purines, pyrimidines, nucleotides, and oligonucleotides; nucleic acids; genetics and biology; and physical and chemical data. Also included is a chapter on abbreviations and nomenclature, and a 3-foot by 4-foot chart of biochemical pathways showing several hundred reactions associated with metabolic pathways.

Stecher, P. G., editor. 1968. The Merck index, 8th ed. Merck and Co., Rahway, N.J.

An alphabetical listing of chemicals and drugs by their nonproprietary or trivial names. Each entry includes, as far as possible, synonyms, chemical formula, molecular weight, chemical analysis, source or preparation, physical properties, chemical properties, nonmedical use, medical use, and veterinary use. A cross index of names and a formula index provide a very useful key to the location of information on a specific chemical or drug.

Weast, R. C., editor. 1969–1970. Handbook of chemistry and physics, 50th ed. Chemical Rubber Co., Cleveland, Ohio.

The classic handbook of mathematical tables, tables of inorganic and organic compounds (including synonyms and formulas, molecular weight, crystalline form, refractive index, density, melting point, boiling point, and solubility); general chemical tables, tables of general physical constants, and miscellaneous tables of chemical and physical data. A complete list of factors for converting units of measure from and to the metric system is included.

Weir, D. M., editor. 1967. Handbook of experimental immunology. F. A. Davis Co., Philadelphia, Pa.

A narrative volume covering the underlying principles, practical details, and applications of some widely used procedures in experimental and applied immunology. Sections of the book cover antibodies, antigens, methods for the study and demonstration of antigen-antibody interaction, methods for the study of cellular and transplantation immunity, and methods for the study of allergic reactions.

ZOOLOGICAL NOMENCLATURE

American Society of Parasitologists, Committee on Common Names. 1953. A preliminary list of common names for helminths. J. Parasitol. 39:348–351.

A simple listing of scientific names and corresponding common names of Nematoda, Cestoda, Trematoda, and Acanthocephala.

Anderson, S., and J. K. Jones. 1967. Recent mammals of the world. Ronald Press Co., New York, N.Y.

A concise summary of each of the 20 orders and 122 families of living or recently extinct mammals. Information on diagnosis (distinguishing characteristics), recent distribution, geologic range, and families is provided for each order. The account for each family includes diagnosis, general morphological features, habits, habitat, recent distribution, recent genera, geologic range, major fossil groups, and remarks.

Bailey, Reeve M., chairman. 1970. A list of common and scientific names of fishes from the United States and Canada, 3rd ed. American Fisheries Society, Washington, D.C.

A listing of 2,131 species of fishes arranged in classes, orders, and families. Common name, occurrence (Atlantic, Pacific, freshwater), and scientific name are given for each fish. Two indexes are included, one giving common names and the other scientific names.

Blackwelder, R. E. 1963. Classification of the animal kingdom. Southern Illinois University Press, Carbondale, Ill.

A complete classification, including phyla, classes, orders, and geologic range, of all animals, living and fossil. The bibliography of major recent classifications, and the indexes to common and Latin names, are very useful.

Blickenstaff, C. C., chairman. 1970. Common names of insects approved by the Entomological Society of America. Entomological Society of America, College Park, Maryland.

A list of common names of insects with their corresponding scientific names, a list of scientific names of insects with their corresponding common names, and a list of phylum, class, order, and family names of insects. This edition is published separately; the previous edition was part of the December, 1965, issue of the *Bulletin of the Entomological Society of America.*

Borrer, D. J., and D. M. DeLong. 1971. An introduction to the study of insects, 3rd ed. Holt, Rinehart and Winston, New York, N.Y.

The insect orders constitute separate chapters in this book, with each chapter including a classification, plus a key to identification, of the families in the order. A discussion of each family

includes specific anatomical characteristics, distribution, and habits, as well as mention of the most common species. Illustrated.

Carr, A. F. 1952. Handbook of the turtles of the United States, Canada, and Baja California. Comstock Publishing Associates, Ithaca, N.Y.

An account of the 79 species and subspecies that inhabit the United States, Canada, and Baja California. It includes keys to identification of the families and genera, and for each turtle describes range, distinguishing features, description, habitat, habits, breeding, feed, and, if appropriate, economic importance. Illustrated.

Cochran, D. M. 1961. Living amphibians of the world. Doubleday and Co., Garden City, N.Y.

A discussion of life cycle, range, distribution, defense mechanism, feeding, and adaptation of living caecilian, salamander, frog, and toad families, as well as descriptions of more than 350 species; 220 photographs of amphibians (77 in color).

Dawes, B. 1946. The Trematoda. Cambridge University Press, New York, N.Y.

A detailed classification and description of all the families of trematodes, including the more common genera, with keys to their identification. Additional chapters cover anatomy, larval stages, life histories, reproduction, distribution, phylogeny, biology, history, and techniques. Illustrated.

Gilliard, E. T. 1958. Living birds of the world. Doubleday and Co., Garden City, N.Y.

A discussion of general characteristics, relationships, number of species, range, origin, centers of abundance, mating, breeding, and parental care of living bird families and subfamilies. Descriptions of almost 1,500 species are included; 400 photographs of birds (217 in color).

Herald, E. S. 1961. Living fishes of the world. Doubleday and Co., Garden City, N.Y.

A discussion of habits, range, feeding, and life cycles of living jawless, cartilaginous, and bony fish families, as well as descriptions of almost 1,000 species; 300 photographs of fishes (145 in color).

Kudo, R. R. 1966. Protozoology, 5th ed. Charles C Thomas, Springfield, Ill.

A taxonomic arrangement of free-living and parasitic Protozoa. Descriptive information is given for each genus and for the common and representative species. Additional chapters cover ecology, morphology, physiology, reproduction, variation, and heredity. Illustrated.

Napier, J. R., and P. H. Napier. 1967. A handbook of living primates. Academic Press, New York, N.Y.

A systematic listing of the 56 genera of living primates, with the scientific species and corresponding common names. For each genus, information is provided on geographical range, ecology, morphology, genetics, behavior, development and reproduction, and captivity. Illustrated.

Rothschild, N. M. V. 1965. A classification of living animals. John Wiley & Sons, New York, N.Y.

A taxonomic classification of living vertebrates and invertebrates according to phyla, classes, and orders, with examples of the better known genera for each order. An "Animal and Group Index" lists 4,000 of the more common or representative genera, plus identifying order or suborder for each genus; many common names of genera are given.

Schmidt, K. P., and R. F. Inger. 1957. Living reptiles of the world. Hanover House, Garden City, N.Y.

A discussion of the behavior and life histories of living turtle, crocodile, lizard, and snake families, and of the tuatara. Descriptions of approximately 1,000 species are included: 266 photographs of reptiles (145 in color).

Simpson, G. G. 1945. The principles of classification and a classification of mammals. Bull. Amer. Mus. Nat. Hist. 85.

A detailed classification of mammals by hierarchic category. Included are technical names, authors and years of publication, synonyms, known geological and geographical distribution of families, and common names of genera. An index of scientific names and another index of common names of genera are important parts of the bulletin.

Smith, H. M. 1946. Handbook of lizards. Comstock Publishing Associates, Ithaca, N.Y.

An account of the 136 species and subspecies of lizards native to the United States and Canada. It includes keys to identification of the genera and species, and for each lizard describes range, size, color, scalation, recognition characters, habitat, habits, and problems. Illustrated.

Wardle, R. A., and J. A. McLeod. 1968. The zoology of tapeworms. Hafner Publishing Co., New York, N.Y.

A detailed classification and description of all the families of tapeworms, with keys to identification of the genera and species. Additional chapters cover anatomy, physiology, life cycles, biology, evolution, and history. Illustrated.

Wetmore, Alexander, chairman, Committee on Classification and Nomenclature. 1957. Check-list of North American birds, 5th ed. American Ornithologists' Union, Washington, D.C.

A listing of 1,683 species and subspecies by scientific name followed by the common name and an outline of the species range. Breeding and wintering information is provided. The check-list is arranged according to orders and families.

Wright, A. H., and A. A. Wright. 1949. Handbook of frogs and toads. Comstock Publishing Associates, Ithaca, N.Y.

An account of the 100 species and subspecies of frogs and toads that inhabit the United States and Canada. Includes keys to identification of families, and for each species describes range, habitat, size, general appearance, color, structure, voice, and breeding. Illustrated.

Wright, A. H., and A. A. Wright. 1957. Handbook of snakes. 2 vols. Comstock Publishing Associates, Ithaca, N.Y.

An account of the 305 species and subspecies of snakes native to the United States and Canada. Includes keys to identification of families and genera, and for each snake describes range, size, longevity, distinctive characteristics, color, habitat and habits, period of activity, breeding, food, enemies, and, if appropriate, venom. Illustrated.

BOTANICAL AND MICROBIOLOGICAL NOMENCLATURE

Ainsworth, G. C. 1961. Ainsworth & Bisby's dictionary of the fungi. Commonwealth Mycological Institute, Kew, Surrey, England.

An alphabetical listing of all the generic names of fungi, including their systematic position, distribution, and number of species. In addition, short accounts of the chief families, orders, and classes of fungi; explanations of words used in mycology; and the common names of important fungi. A separate "Systematic Arrangement of the Genera of Fungi" and a "Key to the Families of Fungi" complete the dictionary. Illustrated.

American Committee on Arthropod-Borne Viruses. 1969. Arbovirus names. Amer. J. Trop. Med. Hyg. 18:731–734.

The names and abbreviations and official catalog numbers for all the arboviruses named throughout the world given in tabular form for easy reference. In addition, the names of the antigenic groups to which these viruses belong are arranged in tabular form, along with their abbreviations. The Committee offers six simple rules for naming of arboviruses.

American Joint Committee on Horticultural Nomenclature. 1942. Standardized plant names. J. Horace McFarland Company, Harrisburg, Pa.

An alphabetical listing of approved scientific and common names of vascular plants, and of plant products in American commerce or use. For each approved genus and species (shown in boldface), the corresponding common name is given; for each approved common and horticultural variety name (shown in small capitals), the corresponding scientific name is given. Synonyms or unapproved names (shown in italics) are included.

Breed, R. S., E. G. D. Murray, and N. R. Smith. 1957. Bergey's manual of determinative bacteriology. Williams & Wilkins Co., Baltimore, Md.

A systematic classification of bacteria and rickettsia, with keys to identification of families and genera within an order. A description of each species is included; it covers morphological, cultural, physiological, and pathogenic characteristics. "A Comprehensive Key to the Genera of the Manual" and an "Index of Scientific Names" complete the book.

Buchanan, R. E., J. G. Holt, and E. F. Lessel, Jr. 1966. Index Bergeyana. Williams & Wilkins Co., Baltimore, Md.

A companion volume to *Bergey's Manual of Determinative Bacteriology*. It lists alphabetically all the published names of bacterial taxa and all the epithets (specific and subspecific) for each genus—approximately 28,900 entries. Separately it lists the authors and titles of the first proposed names or descriptions of taxa, alphabetized under the names of senior authors.

Fernald, M. L. 1950. Gray's manual of botany. 8th ed. American Book Company, New York, N.Y.

A systematic classification of the flowering plants and ferns of the central and northeastern United States and adjacent Canada, with keys to identification of genera and species within a family. Thorough descriptions of more than 8,000 species, varieties, forms, and named hybrids are included, plus information on flowering periods and ranges. Two separate indexes are provided, one to Latin names of families, genera, and species, and the other to English, French-Canadian, and colloquial names. Illustrated.

Hale, M. E., Jr. 1961. Lichen handbook. Smithsonian Institution, Washington, D.C.

A key to identification of genera and species of lichens in the forests of temperate eastern North America. Information is provided on morphology and anatomy, reproduction, physiology and growth, symbiosis, chemistry, phytogeography, and economic uses. Illustrated.

Hale, M. E., Jr., and W. L. Culberson. 1960. A second checklist of the lichens of the continental United States and Canada. Bryologist 63:137–172.

An alphabetical listing of 196 lichen genera (2,492 species) recorded in the continental United States and Canada. A separate list of synonyms and other noncurrent epithets or excluded names is provided.

Lewin, R. A., editor. 1962. Physiology and biochemistry of algae. Academic Press, New York, N.Y.

A review of the study of algae as living organisms. Includes nutrition and metabolism, composition of cells and metabolic products, physiology of whole cells and plants, and physiological aspects of ecology. A valuable appendix is the table of classification indicating taxonomic relationships among the various genera mentioned in the book.

Martyn, E. B., editor. 1968. Plant virus names: an annotated list of names and synonyms of plant viruses and diseases. Phytological Papers No. 9 of the Commonwealth Mycological Institute, Kew, Surrey, England.

An accepted standard for names of plant viruses.

Willis, J. C. 1966. A dictionary of the flowering plants and ferns, 7th ed. Cambridge University Press, New York, N.Y.

An alphabetical listing of all published generic names (from 1753 onward) and family names (from 1789) of vascular plants, totaling 40,000 entries. Variant spellings and intergeneric hybrids have been included. A "Key to the Families of Flowering Plants" is given at the back of the dictionary.

14. Literature Cited

The items listed below represent the literature cited in chapters other than Chapter 4. Any citation for Chapter 4 is at the end of the section to which it applies.

ACCESS. 1969. Key to the source literature of the chemical sciences. American Chemical Society, Columbus, Ohio.

American Men of Science. 1965–1967. A biographical directory edited by the Jaques Cattell Press, 11th ed. The physical and biological sciences. 6 vols. + 5 supplements, 1966–1969. R. R. Bowker Company, New York, N.Y.

American Ornithologists' Union. 1957. Checklist of North American birds. American Ornithologists' Union. Port City Press, Baltimore, Md.

ANSI (American National Standards Institute). 1969. American national standard for the abbreviation of titles of periodicals. American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

———. 1970. ISO recommendation R1000. American National Standards Institute, 1430 Broadway, New York, N.Y.

ASTM (American Society for Testing Materials) Committee on Metric Practice. 1970. Standard metric practice guide. American Society for Testing Materials, Philadelphia, Pa.

Baker, S. 1956. Scholarly style, or the lack thereof. Amer. Ass. Univ. Professors Bull. 42:464–470.

Biological Abstracts List of Serials with Title Abbreviations. [Published each January.] BioSciences Information Service of Biological Abstracts, Philadelphia, Pa.

Blickenstaff, C. C., chairman. 1970. Common names of insects approved by the Entomological Society of America. Entomological Society of America, College Park, Md.

Dorland's Illustrated Medical Dictonary, 24th ed. 1965. W. B. Saunders Company, Philadelphia, Pa.

Enzyme nomenclature: recommendations (1964) of the International Union of Biochemistry on the nomenclature of enzymes, together with their units and the symbols of enzyme kinetics. American Elsevier Publishing Company, New York, N. Y.

Follett, W. 1966. Modern American usage: a guide. Hill & Wang, New York, N.Y.

Fowler, H. W. 1965. A dictionary of modern English usage, 2nd ed., revised by Sir Ernest Gowers. Clarendon Press, Oxford, England.

Index Medicus (published monthly) and Cumulated Index Medicus (published annually). National Library of Medicine, Bethesda, Md.

Kesling, R. V. 1958. Crimes in scientific writing. Turtox News 36(12):274–276.

Lasky, J. 1954. Proofreading and copy-preparation. The Mentor Press, New York, N.Y.

McGlashan, M. L. 1970. Manual of symbols and terminology for physicochemical quantities and units adopted by the IUPAC Council (1969). Pure Appl. Chem. 2:1–44.

Paul, M. 1971. The International System of Units (SI)—development and progress. J. Chem. Doc. 11:3–8.

Riker, A. J. 1946. The preparation of manuscripts for Phytopathology. Phytopathology 36:953–977.

Sober, H. A., editor. A synopsis by Waldo E. Cohen of the recommendations of the IUPAC-IUB Commission on Biochemical Nomenclature. Handbook of Biochemistry, 2nd ed. Chemical Rubber Company, Cleveland, Ohio.

Titus, E. B. 1965. Union list of serials in libraries of the United States and Canada, 3rd ed. 5 vols. The H. W. Wilson Company, New York, N.Y.

Trelease, S. F. 1969. How to write scientific and technical papers. M.I.T. Press, Cambridge, Mass.

United States Geological Survey. 1958. Suggestions to authors of the reports of the United States Geological Survey, 5th ed. U.S. Government Printing Office, Washington, D.C.

University of Chicago Press. 1969. A manual of style, 12th ed. rev. University of Chicago Press, Chicago, Ill.

U.S. Government Printing Office. 1967. Style manual, revised edition. U.S. Government Printing Office, Washington, D.C.

Webster's New International Dictionary of the English Language. 1932. G. & C. Merriam Company, Springfield, Mass.

Webster's New International Dictionary of the English Language, Second Edition, Unabridged. 1941. G. & C. Merriam Company, Springfield, Mass.

Webster's Seventh New Collegiate Dictionary. 1963. G. & C. Merriam Company, Springfield, Mass.

Webster's Third New International Dictionary of the English Language, Unabridged. 1961. G. & C. Merriam Company, Springfield, Mass.

Index

Abbreviations and symbols, 46–50, 219–248
  abbreviation of periodical titles in list of references, 159–160
  chromosome and gene symbols, 69–78
  coining of, 47, 219
  copy editor's guide to, 223–248
  for amino acids in polypeptides and proteins, 106–108
  for blood groups, 83–84
  for centrifuging data, 104–105
  for chemicals, 48, 98
  for drugs, 48
  for gas variables in respiratory physiology, 90–93
  for geographic names, 48
  for geologic names, 48
  for glucose-6-phosphate dehydrogenase, 86–87
  for hemoglobins, 84–86
  for human complement components, 81
  for human immunoglobulins, 79–81
  for metabolic quotients, 105
  for monosaccharide units in oligo- and polysaccharides, 109–110
  for nuclides and isotopes, 100–101
  for RNA fractions or functions, 106
  for scientific names, 49–50
  for serum groups, 83–84
  for units of measurement, 48–49
  gene symbols for yeasts, 72
  gene symbols for mouse, 74–75
  genotype symbols for bacteria, 70–71
  in abstract of article, 47
  in figures, 47
  in graphs, 144
  in hematology, 82–88
  in human cytogenetics, 76–78
  in illustrations, 144
  in mathematical formulas and equations, 112–116
  in respiratory physiology, 90–93
  in specialized fields, 50
  in statistics, 118
  in tables, 47, 141
  in text matter, 46–47
  in thermal physiology, 88–92
  in title of article, 47
  in translation of article, 47
  mutation site designations for bacteria, 70–71
  phenotype abbreviations for bacteria, 71
  proofreader's symbols and marks, 190–191
  rules for non-use of periods in, 29
  spacing and punctuation of, 50
  standard and nonstandard forms, 219–220, 223–224

  standard forms, listing of, 221–223
  writing of, 50
Abbreviations of chemical compounds, 98
Abstract in article, 1–2, 128–130, 177
  abbreviations in, 47
  form, 129
  informative vs. indicative, 128
  length, 129
  preparation of, 128–130
Acknowledgments in article, 1, 8, 132
Acute accent, 42
Alignment in columns, 139–140
Alleles, 71, 73–75
Alphabet, 121–123
  Greek, 121
  Russian, 122–123
Alphabetization of indexes, 201–202
Although and *while*, use in writing, 21
Amino acid designations, 106–109
Analysis of chemical compounds, 103
Analytical and other methods in chemistry and biochemistry, 103
  analytical method, 103
  procedural method, 103
Anatomy, 68–69, 262–263
  International Anatomical Nomenclature Committee, 68, 262–263
  International Committee on Veterinary Anatomical Nomenclature, 68–69, 263
  nomenclature, 68–69, 262–263
Animals, 74–76, 94–96
  cat, chromosome groups and numbers, 75–76
  cell lines used in tissue culture, description of, 94
  farm animal descriptions, 95
  gnotobiotes, 95
  mouse, gene symbols, 74–75
  outbred animal descriptions, 95
  use in experiments, description of, 94–96
Annotated bibliography, 249–273
Antigens, human histocompatibility leukocyte, 81–82
Apostrophe, 37–38
  in forming possessive of nouns, 37–38
  where not to use, 38
Arabic author names, 156
Article planning, 1–4
  abstract, 1–2
  acknowledgments, 1
  by-line, 1–3
  citing reference material, 4
  conclusions, 1
  descriptors, 1
  discussion, 1–2
  form, 1–3
  illustrations, 4
  indexing terms, 1
  introduction, 1–2
  key words, 1
  literature cited, 1, 4
  materials and methods, 1–2
  published authority, 4
  references, 1
  reproduction of material from other authors, 4
  results, 1–2
  sections, 1
  summary, 1
  supporting evidence in, 3
  tables, 3–4
  title, 1–2
  unpublished authority, 4
Article writing, 5–26
  abbreviations and symbols, guidelines for authors, 221–223
  acknowledgment of authorship of quoted or paraphrased material, 134
  acknowledgments section, 1, 8, 132
  citing copyrighted material, 134–136
  citing reference material, 9, 133–136, 152–166
  description of experimental materials, 93–96
  discussion section, 8
  faulty writing, 23–26
  first draft, 7–11
  footnotes to tables, 141

  footnotes to text, 8, 132–133
  geographic and geological data in, 119–120
  Greek alphabet and its transliteration, 121
  guide to standard abbreviations and symbols, 221–223
  illustrations, 11
  in anatomy, 68–69
  in biochemistry, 96–112
  in botany, 59–68
  in chemistry, 96–112
  in cytogenetics, 69–79
  in genetics, 69–79
  in hematology, 82–88
  in immunology, 79–82
  in microbiology, 59–68
  in physiology, 88–93
  in zoology, 59–68
  introduction section, 7
  jargon in, 14–15
  materials and methods, 7
  mathematical formulas and equations in, 112–115
  omitted words, indication by spaced periods, 30
  person, 5
  quoting or paraphrasing published or unpublished authorities, 133–136
  results, 7
  revisions, early, 11–12
  revisions, later, 12–14
  running head, 130–131
  Russian alphabet and its transliteration, 122–123
  section heads and subheads, 8, 131–132
  style in special fields, 59–123
  statistics in, 115–119
  tables, 11
  tense, 5
  use of copyrighted material, 134–136
  vocabulary, 14–16
  voice, 5–7
  word usage, 17–23
Atomic number, 100
Atoms, number of, 100
Atto, metric prefix, 56
Author citation in taxa, 62–63
Authority, published and unpublished, 4, 10, 133, 152
Author's guide to standard abbreviations and symbols, 221–223
Authorship in bibliographic entries, 162
Authors' names in bibliographies, 154–157
  American, 154–155
  Arabic, 156
  Brazilian or Portuguese, 155
  Chinese, 156
  Dutch; 156
  Egyptian, 156
  French, 155
  Hungarian, 156
  Indian, 157
  Spanish, 155
  Thai, 157
  Vietnamese, 157
Author-supplied indexing terms, 1, 130, 177, 199

Bacteria, 59–68, 70–72, 263, 272
  genetic nomenclature, 70–72
  genotype symbols, 70–71
  identification keys, 65–67
  Index Bergeyana, 60, 272
  International Code of Nomenclature of Bacteria, 59
  mutation site designations, 70–71
  nomenclature, 59–68, 263, 272
  phenotype abbreviations, 71
  plasmids and episomes, symbols for, 71
  plural bacterial names, 64–65
  strain designations, 71–72
  subdivisions of species, 61–62
  vernacular or common names, 64–65
Bacterial genetics, 70–72
  genotype symbols, 70–71
  phenotype abbreviations, 71

  strain designations, 71–72
Because and *since,* use in writing, 21
Bibliographic entries, 162–165
  agency as author in, 163–165
  authorship in, 162
  book listed in, 163
  bulletin listed in, 163
  committee as author in, 163
  editorship in, 163
  illustrations listed in, 164
  microfilm listed in, 165
  newspaper article listed in, 164
  publication of a society listed in, 164
  patent listed in, 164
  reports listed in, 164–165
  series in society publications, 165
  thesis listed in, 165
  translation listed in, 165
Bibliography, 36, 154-157, 249–273
  entries where author's name is repeated, use of dashes, 36, 158
  form of author's names in, 154–157
  of botanical and microbiological nomenclature, 271–273
  of dictionaries and source books, 256–260
  of handbooks, 265–267
  of indexes and periodical lists, 260–261
  of standards and codes, 261–265
  of style manuals, grammars, writing and printing guides, 249–255
  of zoological nomenclature, 267–271
Biochemical nomenclature, reprints of, 110
Blood, 83–84
  clotting factors, 84
  group symbols, 83
Boiling point, 103
Boldface letters, 185
Book in bibliographic entries, 163
Botanical and microbiological nomenclature, annotated bibliography of, 271–273
Botany, 59–68, 72–73, 265, 271–273
  chromosome and gene symbols for maize, tomato, and wheat, 72–73
  gene symbols for flax and oats, 72
  horticultural varieties, 62
  identification keys, 65–67
  International Code of Botanical Nomenclature, 59
  nomenclature, 59–68, 265, 271–273
  subdivisions of species, 61–62
  vernacular or common names, 63–64
Boxhead in tables, 136
Brackets, 36–37
Brazilian author names, 155
Breve or kratkaya, 42
Bulletin in bibliographic entries, 163
By-line in article, 1–3, 127–128
  address and institution in, 127–128
  author named in by-line, 1–3, 127–128
  credit for technical assistance, 128
  given names and initials in, 127

Capital and italic letters, 43, 63, 113, 182–185
Carbohydrate designations, 109–110
  monosaccharides, 109–110
  sugars, 109
Carbon atom designations, 99
Casting off, 185
Cat genetics, 75–76
Categories, 60–62
  basic systematic, 60–61
  infraspecific, 61–62
Cedilla, 42–43
Cenozoic era, 120
Centered period, 30–31
Centi, metric prefix, 56
Checking word division, 39–40, 194–195
Checklist for final draft, 170–171
Chemical names of compounds, 96–97
Chemistry and biochemistry, 96–112
  abbreviations of chemical compounds, 48, 98
  abbreviations of drugs, 48

  analytical methods, 103
  biochemical nomenclature, reprints on, 110
  carbohydrates, 109
  centrifuging, 104–105
  chromatography, 105
  configuration, 101–102
  enzymes, 106, 263
  equations, 101
  formulas, 98–100
  glucose-6-phosphate dehydrogenase, human, 86–87
  hemoglobins, 84–86
  isotopes, 100–101
  lipids, 110
  metabolic quotients, 105
  nomenclature, 96–112
  nonproprietary names, 96–97
  nuclides, 100–101
  physical properties, 103–104
  polynucleotides, 108–109
  polypeptides and other polymers, 106–109
  procedural methods, 103
  proprietary names, 97–98
  reporting of analytical results, 103
  ribonuncleic acid, 106
  rotation, 101–102
  solutions, 102
  spectrophotometry, 104
  steroids, 110
  symbols, 98–100
  water of hydration, 101
Chinese author names, 156
Chromatography reporting, 105
Chromosome symbols, 72–78
  for cat, 75–76
  for fruit fly, 73–74
  for maize, 72
  for man, 76–78
  for tomato, 73
  for wheat, 72
Circled or ringed letter, 42
Circumflex, 42
Citation of author in nomenclature of organisms, 62–63
Clotting factors, human blood, 84
Codes of nomenclature of organisms, 59–65
Codes, annotated bibliography of, 261–265
Coined abbreviations, 47, 219
Coined names of chemical compounds, 97
Colon, 34–35
  placement of, 35
  where not to use, 35
  where to use, 34
Columns, 139–141
  alignment in, 139–140
  factors in headings of, 140–141
Comma, 31–34, 41–42
  in punctuating series and enumerations, 41–42
  placement of, 33
  where not to use, 33–34
  where to use, 31–33
Committee as author in bibliographic entries, 163
Common names of organisms, 63–65, 267–273
  bibliography of, 267–273
  lists of, 63–65
Complement designations, human, 81
Compound terms in article, 43–45
  derived from adverb and verb, 45
  derived from preposition and noun, 45
  use of hyphen in, 44–45
  word list, 205–218
  writing of, 44–45
Concentration of solutions, 102
Concise writing, 23–26
Conclusions in article, 1
Configurational relationships of chemical compounds, 101–102
Confusing pairs of words, 20–21
Copy, reading final draft, 168–169
Copy editor, 179, 186, 223–248
  guide to abbreviations and symbols, 223–248
  sample manuscript page marked for printer, 186
  work with manuscript, 179

Copy fitting, 185
Copy preparation, 125–165
  abstract in article, 1–2, 128–130
  acknowledgments, 1, 8, 132
  alignment of entries in table columns, 139–140
  by-line, 1–3, 127–128
  checking figure numbers and citations, 151
  continuous-tone drawings, 145–146
  cross rules in tables, 137
  descriptors in article, 1, 130
  dimensions and scaling of figures, 146–148
  examples of bibliographic entries, 162–165
  factors in column headings of tables, 140–141
  footnotes to tables, 141
  footnotes to text, 8, 47, 132–133
  heads and subheads, 8, 131–132
  illustrations, 4, 11, 142–152
  illustrations mentioned in list of references, 161
  indexing terms in article, 1, 130
  key words in article, 1, 130
  leaders in tables, 141
  legends for figures, 151–152
  lettering of illustrations, 148–150
  line illustrations, 143–145
  list of references, 152–161
  marking illustrations, 150–151
  missing bibliographic details in list of references, 161
  name of periodical in list of references, 159–160
  names of authors in list of references, 154–157
  parts of tables, 136–137
  photographs, 145–146
  published authority, 4, 133–136
  running head, 130–131
  style for name-and-year system in list of references, 9–10, 153
  style for number system in list of references, 10, 153–154
  symbols and abbreviations in tables, 141
  table numbers, 137
  table titles, 137
  tables, 3–4, 11, 136–141
  title of article, 1–2, 126–127
  title of article or book in list of references, 158–159
  typing of tables, 141
  unpublished authority, 4, 133–136
  vertical rules in tables, 137–139
  volume and pages of book in list of references, 161
  volume, issue, and pages of periodical in list of references, 160–161
  year of publication in list of references, 157–158
Copyrighted material, 134–136
  guidelines in use of, 134–136
  requesting permission for use of, 135–136
Corrections, 169, 188–194
  in final draft, 169
  in proof, 188–194
  in typewritten composition, 194
Cross rules in tables, 137
Cyrillic alphabet, transliteration table, 122–123
Cytogenetic nomenclature, 69–79

Dangling participles and infinitives, 19
Dashes, 35–36
  em, 35
  3-em, 35
  en, 35
  in bibliographic entries where author's name is repeated, 36, 158
  indication by hyphens in typescript, 35
  of different lengths, 35
  where to use, 35
Date of publication, 9, 157–158
Deci, metric prefix, 56
Decimal system, 53–57, 139–140
  in scientific writing, 53–57
  in tables, 139-140
Derivative words, 45-46

- hyphen in, 46
- words with prefixes, writing of, 45–46

Deka, metric prefix, 56
Deoxyribonucleic acid virus nomenclature, 60
Descriptors, 1, 130, 177
Diacritical marks, 42–43
- in European languages, 42–43
- substitutes for, in various languages, 43
- transliterated, 42

Diagonal, 40, 49
Dictionaries and source books, annotated bibliography of, 256–260
Dieresis, 42
Discussion in article, 1–2, 8
Draft, final, 167–172
Draft, first, 7–11
Drawings, *see* Illustrations
Drosophila, 73–74
Drug names, abbreviations for, 48
Dutch author names, 156

Editor, 173–177
- referral of manuscripts to referees, 173
- review of manuscripts, 173–177

Editorship in bibliographic entries, 163
Egyptian author names, 156
Electrocardiogram reproduction, 145
Electron micrographs, 146, 150
Electrophoretic pattern reproduction, 145
Ellipsis marks, 30
Enumerations and series, punctuation of, 41–42.
Enzyme nomenclature, 106, 263
Epoch or series, geologic, 119–120
Equations, 101, 112–116
- chemical, 101
- mathematical, 112–116

Era, geologic, 119–120
European languages, diacritical marks in, 42–43
Exclamation mark, 35
Experimental materials, 93–96
- animal tissue culture, 94
- animals in experiments, 94–96
- plants and animals used in experiments, 93–96

Factors in column headings, 140–141
Family names in bibliographies, 154–157
Faulty writing, 23–26
- concise, 23–26
- examples, 23–26
- nonsense, 26
- sense, 26
- wordy writing, 23–26

Federal agency as author in bibliographic entries, 163–164
Femto, metric prefix, 56
Field of table, 137
Figures (illustrations), 47, 151–152, 169–171
- abbreviations in, 47
- indication of position in final draft, 169–170
- legends for, 151–152
- numbering and citation of, checking, 151
- numbering of, checking in final draft, 171

Final draft, 167–172
- choice of paper, 167
- final checklist of, 170–171
- indication of positions for figures and tables, 169–170
- making corrections and insertions, 169
- reading for errors, 168–169
- submitting to publisher, 171–172
- typing of, 167–168

First draft, 7–11
- acknowledgments, 8
- discussion, 8
- footnotes to text, 8
- heads and subheads, 8
- introduction, 7
- materials and methods, 7
- reference material, citing, 9

  results, 7
  tables and illustrations, 11
Flax genetics, 72
Footnotes, 8, 47, 132–133, 139–141
  in tabular material, 139–140
  to tables, 47, 141
  to text, 8, 132–133
Foreign names, 154–157
Foreign words, diacritical marks in, 43
Form of article, 1–3
Formulas, mathematical, 112–116
French author names, 155–156
Fruit fly genetics, 73–74
  alleles, 73–74
  chromosome aberrations, 74
  genotypes, 73
  mutant types, 73

Galley proofs, 187–197
Gas variables in respiratory physiology, 90–93
Generic names of chemical compounds, 97
Generic names of organisms, 49–50, 60–61
  abbreviation of, 49–50
  basic systematic categories, 60–61
  designating status of, 50
  new genus, species, or variety, 49
Gene symbols, 70–78, 81–82, 84–87
  compilations in Biology Data Book, 70
  compilations in Handbook of Biochemistry, 70
  for fruit fly, 73–74
  for glucose-6-phosphate dehydrogenase, 86–87
  for human hemoglobins, 84–86
  for human histocompatibility leukocyte antigens, 81–82
  for infrahuman hemoglobins, 86
  for maize, wheat, oats, and flax, 72
  for mouse, 74–75
  for tomato, 73
  for yeast, 72
Genetic nomenclature, 69–79
  bacteria, 70–72
  cat, 75–76
  flax, 72
  fruit fly, 73–74
  maize, 72
  man, 76–78
  mouse, 74–75
  oats, 72
  tomato, 73
  wheat, 72
  yeast, 72
Genetics, use of raised period in, 30
Genotype symbols for bacteria, 70–71
Geographic names, 43, 48, 119–120
  abbreviations for, 48
  diacritical marks in, 43
  nomenclature, 119–120
Geology, 48, 119–120
  abbreviations for geologic names, 48
  nomenclature, 119–120
  stratigraphic and time divisions, 120
German author names, 156
German, umlaut substitution in, 43
Giga, metric prefix, 56
Glucose-6-phosphate dehydrogenase nomenclature, 86–87
  genotypic symbol, 87
  phenotypic symbol, 86
Gnotobiotic animals, 95
Grammars, annotated bibliography of, 249–255
Graphs (illustrations), 143–145
Grave accent, 42
Greek alphabet, transliteration table, 121
Guide to abbreviations and symbols, copy editor's, 223–248
Guide to standard abbreviations and symbols, author's, 221–223
Guides, writing and printing, annotated bibliography of, 249–255

Handbooks, annotated bibliography of, 265–267
Heads and subheads, 8, 131–132
Heat, *see* Thermal physiology
Hecto, metric prefix, 56
Hedging, 22

Hematology, 81–88, 90–93
  blood variables in respiratory physiology, symbols for, 90–93
  human blood groups, 83
  human clotting factors, 84
  human complement components, system of symbols for, 81
  human serum groups, 83–84
  infrahuman blood groups, 83
  symbols used in, 82–88
Hemoglobin nomenclature, 84–86
  human, 84–86
  infrahuman, 86
Histocompatibility leukocyte antigens, nomenclature of, 81–82
Horticultural varieties, 62
Hungarian author names, 156
Hydration, water of, 30, 101
  molecules, 101
  use of raised period for, 30
Hyphen, 35–36, 39–40, 44–46, 194–195
  in derivative words, 45–46
  use in chemical or molecular formulas, 39
  use in compound terms, 44–45
  use in dividing words at end of line, 39–40, 196–197
  use to indicate range of numbers, 35–36, 39

Identification keys for organisms, 65–67
  construction of, 65–66
  examples of, 66–67
Illustrations, 4, 11, 142–152, 195–196
  checking numbering and citation of, 151, 171
  checklist for referees in relation to, 176
  continuous-tone drawings, 145–146
  dimensions and scaling of, 146–148
  electron micrographs, 146, 150
  in bibliographic entries, 164
  in first draft, 11
  legends for, 151
  lettering and numbering of, 148–150
  line illustrations, 143–145
  marking of, 150–151
  mention in list of references cited, 161
  oscillograms, electrocardiograms, and electrophoretic patterns, 145
  photographs, 145–146
  photomicrographs, 146, 150
  proof of, 195–196
  selection of, 4, 142–152
  sizing of, 146–148
  symbols in graphs, 144
Immunoglobulin nomenclature, human, 79–82
Immunology, 79–82
  human complement, 81
  human histocompatibility leukocyte antigens, nomenclature, 81–82
  human immunoglobulins, 79–81
  nomenclature, 79–82
Index Bergeyana, 60, 272
Indexes and periodical lists, annotated bibliography of, 260–261
Indexing, 199–204
  alphabetization of terms, disregarding certain prefixes, 202
  alphabetization of terms, word-by-word or letter-by-letter systems, 201–202
  approach to, 199
  author-supplied terms, 1, 130, 199
  checking by referee, 177
  editing of index cards, 203
  elements of index, 200
  from page proofs, 201
  index terms, choice of, 200, 203
  keyword indexes, 199, 202
  mechanics of, 200–204
  of books and journal articles, 199
  preparation of copy for printer, 203–204
  typography of indexes, 204
  unnecessary prepositions or conjunctions in, 200
  use of 3 x 5 cards, 201

Indexing terms, *see* Key words in article
Indian author names, 157
Indicative abstract, 128
Infinitives and participles, dangling, 19
Informative abstract, 128
Infraspecific categories, 61–62
Insertions, 169, 188–194
  in final draft, 169
  in proof, 188–194
International Anatomical Nomenclature Committee, 68
International Code, 59
  of Botanical Nomenclature, 59
  of Nomenclature of Bacteria, 59
  of Zoological Nomenclature, 59
International Committee, 60, 68–69
  on Nomenclature of Viruses, 60
  on Veterinary Anatomical Nomenclature, 68–69
International System of Units, *see* Système International d'Unités
Introduction in article, 1–2, 7
Ionic charge, 100
Isotopes and nuclides, 100–101
Italic and capital letters, 43, 63, 113, 182–185

Jargon, 14–15

Keys for identifying organisms, 65–67
  construction of, 65–66
  examples of, 66–67
Key words in article, 1, 130, 177
Kilo, metric prefix, 56
Kratkaya or breve, 42

Latin names, 49–50, 60–63
  abbreviations for, 49–50
  of organisms, 60–63
Latin words, 49–50, 195
  division of, 195
  used in describing new scientific name, 49
  used in designating status of scientific name, 50
Leaders in tables, 141
Legends to figures and illustrations, 151–152
Lettering illustrations, 148–150
Line illustrations, 143–145
Lipid nomenclature, 110
Listing, 205–273
  of abbreviations and symbols, 219–248
  of annotated references, 249–273
  of frequently used words, 205–218
Literature cited in article, 1, 4, 9–11, 152–166
Literature cited in specialized fields
  anatomy, 69
  botany, 67–68
  chemistry and biochemistry, 110–112
  experimental materials, 96
  genetics and cytogenetics, 78–79
  geography and geology, 120
  hematology, 87–88
  immunology, 82
  microbiology, 67–68
  physiology, 93
  statistics, 119
  zoology, 67–68

Macron, 42
Maize genetics, 72
Manuscript, 171–177, 179–186
  checklist, final, 170–171
  checklist for referees, 175–177
  criticisms and comments, 173
  deposit of portions with National Auxiliary Publications Service, 172, 175
  editor's responsibilities, 173–174
  estimating number of printed pages from, 185
  mailing of, 172
  review by copy editor, 179
  review by editors, 173–177
  review by referees, 173–177
  sample page edited and marked for printer, 186
  setting in type, 179–186

  submitting to publisher, 171–172
Maps, *see* Illustrations
Marking illustrations, 150–151
Marks, proofreader's, 190–191
Mass number, 100
Materials and methods in article, 1–2, 7
Mathematical formulas and equations, 36, 112–115
  grouping expressions within parentheses, 36
  identifying characters, 112–113
  italics in, 113
  presenting complex equations, 113–115
  simplifying equations, 113
Measures, 48–49, 53–57, 89
  abbreviations for, 48–49
  common units and their metric equivalents, 54
  in thermal physiology, 89
  metric and decimal systems, 53–57
Mechanical conventions, 27–57
  compound terms, 43–45
  derivative words, 45–46
  punctuation, 27–43
  style in specialized fields, 59–123
Mega, metric prefix, 56
Melting point, 103–104
Mesozoic era, 120
Metabolic quotients, 105
Metaphor and simile, 22–23
Metric system, 53–57, 140, 261–262
  advantages in tabular material, 140
  equivalents for common units, 54
  in scientific writing, 53–57
  prefixes used in, 56
  standards and codes, bibliography of, 261–262
  Système International d'Unités, 53–57
Micro, metric prefix, 56
Microbiological nomenclature, annotated bibliography of, 271–273
Microbiology, 59–68
Microfilm in bibliographic entries, 165
Milli, metric prefix, 56
Molal solutions, 102
Molar solutions, 102
Mole, 102
Molecular formula, 98
Monosaccharides, abbreviations for, 109–110
Mouse genetics, 74–75
Mutation sites, bacterial, 70–71

Name-and-year system in references, 9–10, 153
Names of authors in bibliographies, 154–157
Names of chemical compounds, 96–98
  chemical names, 96–97
  coinages, 97
  generic names, 97
  nonproprietary, 96–97
  proprietary, 97–98
  source names, 97
  trivial names, 97
Names of drugs, abbreviations for, 48
Nano, metric prefix, 56
National Auxiliary Publications Service, 172, 175
Newspaper article in bibliographic entries, 164
Nomenclature, 68–79, 84, 119–120
  anatomical, 68–69
  in chromatography, 105
  in genetics and cytogenetics, 69–79
  in geography and geology, 119–120
  in hematology, 82–87
  in immunology, 79–82
  in spectrophotometry, 104
Nomenclature, biochemical, 96–112
  carbohydrates, 109–110
  enzymes, 106, 263
  for concentrations of chemical solutions, 102
  glucose-6-phosphate dehydrogenase and its variants, 86–87
  hemoglobins, 84–86
  human histocompatibility leukocyte antigens, 81–82
  human immunoglobulins, 79–81
  lipids, 110

  polypeptides and other polymers, 106–109
  RNA fractions or functions, 106
  steroids, 110
Nomenclature, botanical, 59–68, 265
  bibliography on, 271–273
  horticultural varieties, 62
  identification keys, 65–67
  International Code of Botanical Nomenclature, 59
  subdivisions of species, 61–62
  vernacular or common names, 63–64
Nomenclature, microbiological, 59–68
  bacteriological subdivisions of species, 61–62
  bibliography on, 271–273
  DNA virus nomenclature, 60
  International Code of Nomenclature of Bacteria, 59
  International Committee on Nomenclature of Viruses, 60
  plural bacterial names, 64–65
  RNA virus nomenclature, 60
  vernacular or common names, 63–65
Nomenclature, zoological, 59–68
  bibliography on, 267–271
  identification keys, 65–66
  International Code of Zoological Nomenclature, 59, 264
  International Trust for Zoological Nomenclature, 60, 264
  subdivisions of species, 62
  vernacular or common names, 63–65
Nonsense in writing, 26
Normal solutions, 102
Nouns, 16–18
Nuclides and isotopes, 100–101
  atomic number, 100
  atoms, number of, 100
  ionic charge, 100
  mass number, 100
Number system in references, 10, 153–154
Numbers, 50–57
  metric and decimal systems, 53–57
  ordinal and cardinal, 52
  reporting of, 50–51
  rounding of, 51
  sentences beginning with, 52
  series of, 52
  Système International d'Unités, 53–57
  using words for, 52
  writing of, 51–52
Oat genetics, 72
Of and *which*, overuse in writing, 18–19
Omitted words indicated by spaced periods, 30
Optical rotation of chemical compounds, 101–102
Oscillogram reproduction, 145
Overseas, handling proof for authors, 197
Oxidation state of an element, 98–99

Page proofs, 187–197, 201
  use in preparing index, 201
Pages, estimating number of printed, 185
Pagination of periodical or book, 160–161
Paleozoic era, 120
Paper for final draft, 167
Paraphrasing published or unpublished authorities, 133–136
Parentheses, 36–37
  parentheses within parentheses, 36
  to enclose comment or explanation that is independent, 36
  to group mathematical expressions, 36
  use of, 36–37
Participles and infinitives, dangling, 19
Patent in bibliographic entries, 164
Period, 28–31
  after abbreviation for Latin term, 28
  after abbreviations where omission might cause confusion, 28
  after certain abbreviations, 28

- after declarative sentence, 28
- after imperative sentence, 28
- at end of run-in sidehead, 28
- function of, 28
- placement of, 28–29
- spaced, use of, 30
- where not to use, 29
- where to use, 28

Period or system, geologic, 119–120
Periodical lists, annotated bibliography of, 260–261
Periodicals, 159–161
- abbreviation of periodical names in list of references cited, 159–160
- citing in list of references, 159–160
- volume, issue, and pages in list of references cited, 160–161

Person in writing, 5
Personal communications, 10, 134
Phenotype abbreviations for bacteria, 71
Photographs, 142, 145–147, 150
Photomicrographs, 146, 150
Physical properties of chemical compounds, 103–104
- boiling point, 103
- melting point, 103–104
- specific refractive index, 103
- specific rotation, 103

Physiology, 88–93
- respiratory physiology variables, symbols for, 90–93
- thermal physiology, abbreviations and symbols in, 89–92

Pico, metric prefix, 56
Plants, *see* Botany
Polymer designations, 106–109
Polynucleotides, 108–109
Polypeptide and other polymer designations, 106–109
- associated polynucleotides, 108
- nucleotide sequences of codons, 108
- synthetic polypeptides, 108
- synthetic polyribonucleotides, 108

Portuguese author names, 155
Precambrian era, 120
Prefixes, 45–46, 56
- for multiples of metric system, 56
- in derived words, 45–46

Preparation of copy, instructions, 125–165
Printed pages estimated from manuscript, 185
Printer's measurements, 180–182
- em, 180–181
- en, 181
- pica, 181–182
- point, 181–182

Printing guides, annotated bibliography of, 249–255
Proof, 187–197
- addition of material after reading of, 193
- checking word division on, 194–195
- galley proofs and page proofs, 187–188
- handling proof for overseas authors, 197
- marking of, 189, 193–194
- of illustrations, 195–196
- questions from editor or printer on, 193
- reading of, 188–189
- sample of galley proof marked for corrections, 192
- typewritten composition, correction of, 194

Proofreader's symbols and marks, 189–193
Properties of chemical compounds, 103–104
Proprietary names, 97–98
- trademarks, 97
- trade names, 97

Protein designations, 106–109
Publication date in references, 157–158
Publication of a society in bibliographic entries, 164
Published authority, 4, 133–136
Punctuation, 27–43
- apostrophe, 37–38
- brackets, 36–37

  brackets in quoting published and unpublished authorities, 133
  colon, 34–35
  comma, 31–34, 41–42
  dashes, 35–36
  deletion of excessive, 27
  diacritical marks, 42–43
  ellipsis marks, 30
  exclamation mark, 35
  hyphen, 35, 39–40
  italics and capitals, 43, 63, 113, 182–185
  leaders in tables, 141
  of abbreviations, 50
  of series and enumerations, 41–42
  parentheses, 36, 41
  period, 28–31
  question mark, 35
  quotation marks, 38–39
  raised period, 30–31
  relationship of quotation marks to other punctuation marks, 39
  rules, 27–43
  semicolon, 34, 41–42
  series and enumerations, 41–42
  slant line, 40
  spaced periods, 30
  spaced periods in tables, 141
  underpunctuated sentences, 28
  unnecessary, 27

Question mark, 35
Quotation marks, 38–39
  double, use of, 38–39
  non-use with indirect quotation, 39
  relationship to other punctuation marks, 39
  single, use of, 39
Quotients, metabolic, 105
Quoting published or unpublished authorities, 133–136

Radioisotopes, *see* Nuclides and isotopes
Raised period, 30–31
  for ellipsis in mathematical matter, 31
  in genetic expressions, 30
  in indicating chemical bonds, 30
  in indicating multiplication, 31
  in indicating water of hydration in chemical formulas, 30
  spacing in typescript, 31
  uses of, 30–31
Random design, statistical, 116–117
Referees, 173–177
  checklist for, 175–177
  good practices for, 174–175
  review of manuscripts, 173–177
Reference marks to identify footnotes, 132–133, 141
References in article, 1, 4, 9–11, 152–166
  abbreviation of periodical names in, 159–160
  addition of missing bibliographic details to item in, 161
  American names, 154–155
  Arabic names, 156
  author names, 154–157, 163
  author's preference in spelling of family name, 154–155
  book entries, examples, 163
  Brazilian names, 155
  checking in final draft, 170
  checklist for referees in relation to, 177
  Chinese names, 156
  citing of periodicals in, 159–160
  compound family names of foreign origin, 154–155
  Dutch names, 156
  Egyptian names, 156
  examples of bibliographic entries, 162–165
  federal agencies as authors, examples, 163–164
  French names, 155–156
  German names, 156
  Hungarian names, 156
  illustrations mentioned in, 161
  Indian names, 157
  missing bibliographic details, 161
  name-and-year system, 9–10, 153

  name of periodical, 159–160
  names of authors, 154–157
  number system, 10, 153–154
  Portuguese names, 155
  publications of societies, examples, 164
  quoting or paraphrasing published or unpublished authorities, 133–136
  Spanish names, 155
  Thai names, 157
  title of article or book, 158–159
  unpublished material, 9–10
  unread published material, 10-11
  Vietnamese names, 157
  volume and pages of book, 161
  volume, issue, and pages of periodical, 160–161
  year of publication, 157–158
Refractive index, specific, 103
Report in bibliographic entries, 164–165
Repository for excess article material, 172
Respiratory physiology, 90–93
Results in article, 1–2, 7
Review of manuscripts, 173–177
Revisions of article, 11–14
  early, 11–12
  later, 12–14
Ribonucleic acid, 60, 106
  designations, 106
  virus nomenclature, 60
Ringed or circled letter, 42–43
Rotation, 101–103
  optical, of chemical compounds, 101–102
  specific, 103
Rounding of numbers, 51
Rules, 27–43, 183–185
  for capitalization, 183–185
  for punctuation, 27–43
Running heads in article, 130–131
Russian alphabet, transliteration table, 122–123

Scaling of illustrations, 146–148
Scandinavian languages, diacritical marks in, 42–43
Scientific names of organisms, 49–50, 60–63, 267–273
  abbreviations for, 49–50,
  author citation for, 62–63
  bibliography of, 267–273
  categories of, 60–62
Scientific terms, 205–218
Semicolon, 34, 41–42
  in punctuating series and enumerations, 41–42
  placement of, 34
  where not to use, 34
  where to use, 34
Sense in writing, 26
Series and enumerations, punctuation of, 41–42
Series or epoch, geologic, 119–120
Series publication in bibliographic entries, 165
Serum group symbols, 83–84
Shilling mark, 40, 42
Simile and metaphor, 22–23
Since and *because*, use in writing, 21
Slant line, 40, 49
  as mathematical sign for division, 40
  to show rates or concentrations, 40
  use in names of units of measure, 49
  where not to use, 40
  where to use, 40
Slash, 42
Small capital letters, 183
Soft sign, 42
Solidus, 40
Solution concentrations, 102
  molal solutions, 102
  molar solutions, 102
  normal solutions, 102
Source names of chemical compounds, 97
Spaced periods, 30
Spanish author names, 155
Specialized fields, 50, 59–123
Specialized fields, abbreviations in, 50
Specifications, journal, 180–182

Specific refractive index, 103
Specific rotation, 103
Spectrophotometry reporting, 104
Spelling of words, 205–218
Standard design, statistical, 116
Standard deviation, 117–118
Standard error, 117–118
Standards and codes, annotated bibliography of, 261–267
Statistics reporting, 116–119
  abbreviations and symbols in, 118
  analyses of variance and covariance, 117
  computer print-outs as manuscript or typesetter's copy, 118
  meaningful digits, 117
  random design, 116–117
  standard design, 116
  standard deviation and standard error, 117
Steroid nomenclature, 110
Stød or slash, 42–43
Storage of excess article material, 172
Strain designations for bacteria, 71–72
Stratigraphic divisions, 119–120
Stroke, 40, 42
Structural formulas, 99–100
Stub of table, 137–138
Style manuals, grammars, writing and printing guides, annotated bibliography of, 249–255
Subheads and heads, 8, 131–132
Subscript and superscript characters, 89–93, 98–109
  chemical symbols and formulas, 98–101, 103
  chromatography ratio designation, 105
  genetic symbols, 72, 74
  hematology symbols, 84, 86
  immunology symbols, 80–81
  metabolic quotient symbols, 105
  nuclide and isotope designations, 100–101
  physical property designations, 103
  physiology symbols, 90–93
  polypeptide and other polymer designations, 107–108
  ribonucleic acid designations, 106
  spectrophotometry symbols, 104
  ultracentrifuge data abbreviations, 104–105
Suffixes in derived words, 45–46
Summary in article, 1
Superior dot, 42
Symbols, *see* Abbreviations and symbols
Symbols and formulas, chemical, 98–100
  carbon atom designations, 99
  molecular formula, 98
  oxidation state of an element, 98-99
  simple formula, 98
  structural formulas, 99–100
  use of hyphen in, 39
Symbols for metabolic quotients, 105
Symbols for variables, 88–93
  in respiratory physiology, 90–93
  in thermal physiology, 89–92
Symbols in graphs, 144
Symbols, proofreader's, 190–191
Symbols to identify footnotes, 132–133, 141
Symbols used on geologic maps, 120
Symbols used in human cytogenetics, 76–78
Symbols used in statistics, 118
Systematic categories, basic, 60–61
System or period, geologic, 119–120
Système International d'Unités, 53–57
  abbreviation of names of units in, 49
  basic units of, 53–54
  derived units of, 55
  in scientific writing, 53–57
  standard prefixes in, 56
  supplementary units of, 55

Tables, 3–4, 11, 136–141
  abbreviations in, 47, 141
  alignment in columns of, 139–140
  boxhead, 136–138

- checking numbering of in final draft, 170–171
- checklist for referees in relation to, 177
- cross rules and vertical rules in, 137–139
- deposit of portions with National Auxiliary Publications Service, 172, 175
- examples of, 138–139
- factors in column headings, 140–141
- field, 137–138
- footnotes to, 136–138, 141
- headnotes to, 137–138
- indication of position in final draft, 169–170
- in first draft, 11
- leaders or spaced periods in, 141
- number and title, 136–138
- numbering of, 137
- parts identified in sample table, 138
- parts of, 136–138
- stub, 137–138
- symbols in, 141
- titles of, 137–138
- typing of, 141

Taxa, 60–67
Taxonomy, 49–50, 60–67
- basic systematic categories, 60–61
- citation of authors of species, 62–63
- horticultural varieties, 62
- identification keys, 65–67
- infraspecific categories, 61
- scientific names, abbreviations for, 49–50
- subdivisions of species, 61–62
- typography of scientific names, 63
- vernacular or common names, 63–65

Technical terms, 21–22
Tense in writing, 5
Tera, metric prefix, 56
Terms, 43–45, 205–218
- compound, 43–45, 205–218
- scientific, 205–218

Text matter, abbreviations and symbols in, 46–47
Thai author names, 157
That and *which,* use in writing, 19–20
Thesis in bibliographic entries, 165
Thermal physiology, 89–92
Tilde, 42
Time, 52–53
- 24-hour time system, 53
- reporting of, 52–53

Tissue culture, description of animal cell lines used in, 94
Title of article, 1–2, 126–127, 177
- abbreviated title as running head, 130–131
- abbreviations in, 47
- capitalization in, 127
- checklist for referees in relation to, 177
- construction of, 126–127
- for final draft, 126
- in list of references cited, 158–159
- superfluous phrases in, 127

Title of book in list of references cited, 158–159
Titles, table, 137
Tomato genetics, 73
Trademarks, 97
Trade names of chemical compounds, 97
Translation in bibliographic entries, 165
Translations, abbreviations in, 47
Transliteration, 121–123
- of Greek alphabet, 121
- of Russian alphabet, 122–123

Trivial names of chemical compounds, 97
Type face and size, 180–182
Typography, 179–186
- boldface, 185
- capitals, 43, 183–185
- conventions accepted by editors and printers, 182–185
- estimating number of printed pages, 185
- italics, 43, 182–183
- in scientific names, 63

  of heads and subheads in article, 131–132
  of indexes, 204
  of mathematical formulas and equations, 112–115
  of tables, 141
  printing specifications, 180–182
  rules for capitalization, 183–185
  setting manuscript in type, 179–186
  small capitals, 183
  spacing, 181
  type size, 181
  typing of final draft, 167–168
  typographic errors, checking of final draft, 168–169
  units of point system, 180–181

Ultracentrifuge data reporting, 104–105
Umlaut, 42–43
Units of measure, 48–49, 53–57, 89, 262
  abbreviations for, 48–49
  common units and their metric equivalents, 54
  in thermal physiology, 89
  metric and decimal systems, 53–57
  standards and codes, bibliography of, 262
  use of slant line in names of, 49
Unpublished authority, 4, 10, 133–136
  citing of, 10
  interagency reports, 134
  personal communications, 134
  quoting or paraphrasing of, 133–136
  reproduction of, 4
Usage of words, 17–23, 205–218

Varieties, horticultural, 62
Verbs, 16–17
Vernacular names of organisms, 63–65
Vertical rules in tables, 137
Vietnamese author names, 157
Virgule, 40
Viruses, 60, 272–273
  DNA virus nomenclature, 60
  International Committee on Nomenclature of Viruses, 60
  nomenclature, 60, 272–273
  RNA virus nomenclature, 60
Vocabulary, 14–16, 22, 205–218
  hedging, 22
  jargon, 14–15
  list of words frequently used in biological literature, 205–218
  new nouns, formation of, 16
  new verbs, formation of, 16
  new words, 15–16
Voice in writing, 5–7
Volume numbers of publications, 160–161

Water of hydration, 30, 101
  molecules of, 101
  use of raised period for, 30
Weights, 48–49, 53–57, 89
  abbreviations for, 48–49
  common units and their metric equivalents, 54
  in thermal physiology, 89
  metric and decimal systems, 53–57
Wheat genetics, 72
Which and *of*, overuse in writing, 18–19
Which and *that*, use in writing, 19–20
While and *although*, use in writing, 21
Word division, checking, 39–40, 194–195
Word list, 205–218
Word usage, 17–23, 43–46, 194–195, 249–255
  compound terms, 43–45
  confusing pairs, 20–21
  dangling participles and infinitives, 19
  derivative words, 45–46
  eponymous terms, 21–22
  examples of faulty writing, 23–26
  jargon, 14–15
  nouns and relative pronouns, overusing, 18
  nouns as modifiers, 18

  of and *which,* overusing, 18–19
  participles and infinitives, dangling, 19
  simile and metaphor, 22–23
  since and *because,* 21
  style manuals and guides, annotated bibliography of, 249–255
  technical terms, 21–22
  that and *which,* 19–20
  using new words, 15–16
  using words for numbers, 52
  verbs and nouns, 17
  while and *although,* 21
  word divisions on proof copy, checking of, 194–195
Words frequently misspelled or misused, 205–218
Words, new, 15–16
  nouns, formation of, 16
  verbs, formation of, 16
Wordy writing, 23–26
Writing abbreviations, 50
Writing, faulty, 23–26
  concise, 23–26
  examples, 23–26
  nonsense, 26
  sense, 26
  wordy writing, 23–26
Writing guides, annotated bibliography of, 249–255
Writing numbers, 51–52

Year of publication, 9, 157–158
Yeast genetics, 72

Zoology, 59–68, 73–78, 267–271
  chromosome and gene symbols for fruit fly, mouse, cat, and man, 73–78
  nomenclature, 59–68, 267–271
  vernacular or common names, 63–65